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Industrial Technology, Planning, Productivity

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UDC 531.715/088.8/

Increasing Accuracy of Photoelectric Devices for Checking Straightness During Inspection in Turbulent Atmosphere

18610242a Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 88 (manuscript received 31 Mar 87) pp 2-5

[Article by V. A. Merkulov (deceased)]

[Abstract] Inspection of paths longer than a few meters for straightness by means of photoelectric devices is considered and partial compensation of the effect of perturbations in a turbulent ambient atmosphere by active stabilization of the initial straight path at two fixed points is improved by an adaptive control which minimizes the error. The principle is demonstrated on a photoelectric inspection system consisting of a laser as light source at one end, a stationary linear-displacement transducer at the other end, and a movable linear-displacement transducer with a light-beam splitter in a carriage. While the carriage moves from one end to the other, the light-beam splitter on it reflects one part of the laser beam into the moving transducer and passes the other part to the stationary one. Signals from both transducers, including interference signals, are processed by an adaptive compensator array and a filter array. Each compensator stage includes a delay line, an attenuator with automatic regulation, two amplifiers, two squarers, four subtractors, an aperiodic difference-signal averager, and a matching device. The compensation system minimizes the interference dispersion for subsequent maximum interference suppression from stage to stage, with weights of attenuator and delay line in each stage put out by an adjusting device. Figures 3; references 5: 4 Russian, 1 Western (in Russian translation).

UDC 681.786.3

Optical System on Basis of Concentric Objective

18610242b Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 88 (manuscript received 5 Dec 86) pp 26-28

[Article by M. P. Kolosov]

[Abstract] An adaptive optical system for high-precision angle measuring instruments without limitations on the vertical range is described which, in addition to a goniometer and a rotation-angle sensor, includes also a photoelectric transducer, a photoelectric autocollimator, and a special-purpose instrument computer. The goniometer consists of optomechanical elements assembled into two modules: a concentric lens-and-sphere objective, a cantilever bracket, a code dial, a plane mirror all rigidly coupled in the upper module and a readout disc, a rhombic prism, a rectangular prism, a photodetector, a "point" stop, and a plano-convex objective lens all rigidly coupled in the lower module. Each module is tied to a Cartesian system of coordinates, the upper module to a movable one and the lower module to a stationary one. Other optical components include two illuminators, an afocal compensator, a light-splitting cube, another plane mirror, a projecting objective, another photodetector with sensing pad, a field lens, and a shutter. The mechanical structure consists of a base, an outer frame, and an inner frame. Operation of this optical system is analyzed and its accuracy is evaluated on the basis of applicable geometrical relations, considering that in this system the viewing line passes through the point at which the mount axes intersect. Figures 3; references 7: Russian.

UDC 539.234:621.52

Transparent Triple-Layer Coatings Designed for Visible Range of Spectrum and Produced from TiO_2 and SiO_2 By Reactive Spray Activation

18610242c Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 88 (manuscript received 5 Feb 87) pp 36-38

[Article by Ye. U. Kornitskiy, S. I. Oshchepkov, V. N. Ulasyuk and V. M. Khomenko]

[Abstract] The feasibility of minimizing the integral (over the visible range of the spectrum) reflection coefficient of a triple-layer coating on a glass substrate is demonstrated by the results of an experimental study made following a mathematical description of such a coating. A coating of three equally thick layers of different materials was considered for optical glass with a refractive index of 1.52, the middle layer having the largest refractive index and the bottom layer having the smallest one. The bottom layer was produced by reactive spray activation of a TiO_2 and SiO_2 mixture. The middle layer was produced from TiO_2 and the top layer was produced from SiO_2. The results of measurements in an SF-8 spectrophotometer have generally confirmed the theoretical calculations and thus demonstrated the effectiveness of such a coating, with a noticeable discrepancy with the blue-green range of the spectrum only and this discrepancy being evidently caused by nonoptimality of the refractive indexes of the coating layers as well as by a variance of their optical thicknesses owing to technological imprecision. Figures 4; references 14: 7 Russian, 7 Western (2 in Russian translation).

UDC 535.317.2

Algorithm of Control for Two-Mirror System

18610240a Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 31 No 3, Mar 88 (manuscript received 6 Jan 86) pp 83-89

[Article by A. V. Demin, N. Ye. Dimitrov and I. V. Petrov, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] A pair of two rotating plane mirrors for an optical scanning radar is considered, such a pair being placed on a matching device between the two stationary optical systems within their fields of vision and each mirror being mounted in a gimbals so that it rotates about two mutually orthogonal axes. For optimum control of this pair of mirrors, an algorithm is constructed which ensures that a light beam incident on the first one leaves the second one in the appropriate direction with

minimum cutoff or masking. Article was presented by Department of Special Optical Devices. Figures 2; references 5: Russian.

UDC 535.317.6

Aberrations in Noncentered Two-Mirror Systems
18610240b Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian
Vol 31 No 3, Mar 88 (manuscript received 4 Nov 86) pp 89-93

[Article by S. G. Zhenovka, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] Successive reflections of a light beam by a nonparallel pair of spherical mirrors, the first one concave and the second one convex, is analyzed for an evaluation of astigmatism and coma on the axis between the two mirrors passing through the center of each. Astigmatism is evaluated with the aid of the Abbe-Young meridional and sagittal invariants. Coma is evaluated with the aid of the M. M. Rusinov invariant, which involves the caustic and its radii of curvature before and behind a mirror surface. Coma, is found to be minimum at some distance between the mirrors which depends on the radius and angle of incidence at the first mirror. The corrective geometrical arrangements for eliminating first astigmatism and then minimizing coma are established on the basis of this analysis (simultaneous correction of both is considered impossible for non-centered systems). Article was presented by Department of Optical Devices Theory. Figures 2; references 4: 3 Russian, 1 Western (in Russian translation).

UDC 621.039.546

Computer-Aided Prediction of Fuel Element Performance in Nuclear Power Plant

18610102 Moscow ATOMNAYA ENERGIYA in Russian Vol 65 No 3, Sep 88 (manuscript received 28 Apr 86, in final version 9 Jul 87) pp 163-169

[Article by V. V. Aleshnya, A. A. Brikova, S. I. Zastrozhnov, L. L. Malanchenko, V. V. Fedotov and V. A. Yamnikov]

[Abstract] Predicting the performance of new fuel elements for nuclear power plants is now facilitated by use of a computer for design of new fuel elements, analysis of post-irradiation test data on experimental as well as conventional ones, determination of influencing factors, monitoring the performance of prototype units, and estimating the performance of units for pilot runs under unforeseen as well as foreseen conditions. As physical model of a fuel element has been selected a fuel charge and a gas collector with a helical spacer inside a cylindrical shell between lower and upper end caps, gaseous fission products becoming mixed here with gases evolving during construction of the fuel element. The mathematical model includes differential equations of heat conduction for calculating two-dimensional temperature fields, semiempirical algebraic relations for calculating the temperature dependence of the thermal conductivity and the volume fraction for each component of the gas mixture in three characteristic depletion zones, equations of elasticity for anisotropic materials for calculating the stability characteristics of the shell, and equations of fracture mechanics for determining the possibility of ductile fracture at critical sections. The life of a fuel element is subdivided into successive periods characterized by initial and final depletion levels each, assuming that the depletion rate is a continuous function of time throughout. The criteria of failure have been defined in terms of critical shell temperatures and stresses, critical power levels and gas pressure, seizure, and shape distortion. The software for thus simulating and predicting the performance of a fuel element in a nuclear power plant under steady-state conditions consists of two parts: NET plus TRNSF for calculating two-dimensional temperature fields and RET for all other calculations. All programs are written in FORTRAN language form Minsk-32, BESM-6 high-speed, and YES-1022/1030/1033/1040/1055/1060 computers. On the basis of such calculations have been designed fuel elements for VVER-1000 MW water-moderated water-cooled power reactors, RBMK-100/1500/2400 MW high-power channel reactors, and AST-500 MW nuclear heating plants. Appropriate engineering documentation has subsequently been prepared and reactor cores have been built for Balakovskaya. Ignalinskaya, Kurskaya, Leningradskaya, Novovoronezhskaya (Unit 5), Rostovskaya, Smolenskaya, Khmelnitskaya, Yuzhno-Ukrainskaya, and other AES's as well as for Gorkovskaya and Odesskaya ATETs's. Computer-aided design of fuel elements was also used the VVER-1000 MW water-moderated water-cooled reactor to be installed in the Lovisa-3 AES (Finland), both the project and the software having then be turned over to Finland. The cost effectiveness of this design automation is a saving of 2,000 rubles per design. The cost effectiveness of more complete fuel depletion as a result of optimized fuel element construction and technology is typically a saving of 4.3 million rubles, based on operation of Unit 5 of the Novovoronezhskaya AES in 1985. Figures 5; references 12: 10 Russian, 2 Western (1 in Russian translation).

UDC 533.9.15:662.94

Plasma in Power Engineering

18610086 Alma Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSR in Russian No 8, Aug 88 pp 56-65

[Article by Z. B. Sakipov, doctor of technical sciences, under the rubric "Science for Production": "Plasma in Power Engineering"]

[Text] In the "Basic Directions for the Economic and Social Development of the USSR for 1986-1990 and for the Period to the Year 2000" principal attention is paid to scientific and technical progress and to the development of fundamentally new engineering and technology, first of all for the basic branches of industry. Plasma technology is singled out as one priority direction for the development of new technology.

The unraveling of these problems is particularly urgent for Kazakhstan's raw-energy sources, which are based on local fuel and energy resources, a major part of which constitutes low-grade coal. The majority of the total solid-fuel reserves are comprised of lignite having a high ash content (40 to 50 percent), moisture content (30 to 40 percent) and sulfur content (1 to 5 percent). The presence of a significant quantity of moisture and, the main thing, sulfur (e.g., in the coal of the Turgay Coal Field) does not make it possible to use this coal by the traditional method, i.e., burn it in TES [steam power plant] boilers as a power-generating fuel without prior thermochemical preparation. On the other hand, the consumption of coal in natural form is less efficient as compared to the products of its conversion (synthesis gas and liquid fuel), and with the direct burning of the coal it results in increased pollution of the environment with dust-and-gas effluents. The worsening of the quality of coal strip-mined by the employment of high-productivity methods is making it necessary to constantly "intensify" the high-ash-fuel flame with fuel oil, which runs counter to the general trend toward the elimination of liquid fuel from power generation.

There are various ways of surmounting these difficulties that arise when power-generating units that operate on low-grade fuels are used. A fundamentally new one and the most promising of them, in our opinion, is the method of the thermochemical preparation of coal by using a low-temperature plasma, or the so-called plasma activation method for fuels. The high energy concentration (to 300 MW/m^3) and the presence in the thermal plasma of chemically active atoms (O, H and C), ions (O_2^-, H_2^-, OH^-, C^- and O^-), radicals (OH, CH and HO_2) and electron gas contribute to steadier and more efficient (than in flame methods) combustion and burning of the air-and-coal mixture that has gone through the stage of prior plasma initiation. Let us point out one more not unimportant advantage of using a plasma in power engineering. A low-temperature plasma generator—an electric arc (or some other electrical discharge)—is practically an inertialess heating element, which makes it possible to solve sufficiently reliably the problem of totally automating the process. Along this line, a number of fundamentally new and promising plasma processes, such as the plasma gasification of low-grade coal, starting without fuel oil, and the intensification of the process in pulverized-coal-fired furnaces by using a low-temperature plasma, etc., have been successfully developed during the last 10 to 15 years at the plasma technology laboratory of KazNIIenergetika [Kazakh Scientific Research Institute of Power Engineering].

Some results of theoretical calculation and experimental studies, including stand tests of processes of the plasma activation of low-grade coal, are presented below.

Plasma gasification is the basis of the power engineering conversion of solid fuel. The main goal of the thermal conversion of low-grade fuels is the production of high-calorific and environmentally clean synthesis gas. However, the economic efficiency of the process can be increased significantly if the objective is set of the total power engineering conversion of coal by using a high-temperature plasma. In this case it would be possible to convert more efficiently by means of plasma heating the coal's organic part into synthesis gas ($CO + H_2$) not containing ballasting impurities, and to recover the mineral portion and produce ferrosilicon (Fe_xSi_y), industrial silicon (Si) and silicon carbide (SiC). Moreover, with elevation of the process's temperature level (to 1500 to 2100 K) the coal's original sulfur is totally sublimated and combines into hydrogen sulfide, the cleaning of which from fuel gases has been mastered on an industrial scale.

Studies were conducted with lignite from the Turgay and Podmoskovnyy fields, containing a significant quantity (more than one percent) of sulfur in its composition. The heat engineering characteristics and chemical composition of the ash of these coals are presented in tables 1 and 2.

Table 1. Heat Engineering Characteristics of Coal of Orlovskoye Deposit

Field	Percentage by weight								kcal/kg	
	W^w	A^s	S^s_{tot}	V^b	C^b	H^b	N^b	O^b	Q^a_b	Q^w_n
Turgay	11.8	28.10	1.55	48.00	66.55	4.98	1.00	25.81	4500	3950
Podmoskovnyy	3.0	48.1	2.4	50.0	33.6	6.5	0.88	8.52	3490	2490

Note: W^w and Q^w_n are the moisture content and net heat value of the coal as received; A^s and S^s_{tot} are the total ash content and total sulfur content in the moisture-free coal; V^b, C^b, H^b, N^b and O^b are, respectively, the yield of volatile coal products and the content of carbon, hydrogen, nitrogen and oxygen of the fuel in the dry-and-ash-free coal; and Q^a_b is the oxygen-bomb analytical heat value.

Table 2. Chemical Composition of Ash of Coal of Orlovskoye Deposit

Field	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	SO_3	Other
Turgay	54.01	25.75	7.20	3.82	3.28	2.13	3.81
Podmoskovnyy	53.81	32.04	3.26	0.87	2.60	2.14	5.28

The experimental, highly labor-intensive study of plasma gasification was preceded by numerical calculations according to the multipurpose ASTRA-3 program of the equilibrium states of complex multicomponent heterogeneous systems such as coal. The fundamental laws of thermodynamics together with the laws of the conservation of mass, energy and charge constitute the basis for calculation according to the ASTRA (Automated System for Thermodynamic Calculations) program, which makes it possible to construct for closed thermodynamic systems a mathematical model of the sufficiently general case of the formation and equilibrium of gaseous and condensed matter and electrically neutral components[1]. It should be noted that the ash content of low-grade coal exerts an appreciable influence on the indicators of the gasification process. Therefore, the ASTRA-3 database was supplemented with the missing components characteristic of the mineral portion of high-ash coal (V. Ye. Messerle), which made it possible to obtain a picture closer to reality, reflecting the behavior during plasma conversion of the mineral matter of the coals under discussion.

The results of thermodynamic calculations were then used in a kinetic model of the gasification process as initial conditions in determination of the limiting parameters of the system of equations describing the motion, heating and gasification of pulverized fuel in an oxidant - water vapor stream. All the necessary parameters were calculated by dividing the process of the thermal conversion of goal in an oxidizing atmosphere into a number of successive independent stages. In particular, the degrees of gasification and of the conversion of sulfur to the gas phase were found as a function of the size of the coal particles, the temperature, and the length of time the reacting substances spend in the reaction zone.

It should be noted that the time it takes for the gasification of coal particles of an average size of 250 μm in the reacting substance temperature range of 1500 to 1700 K (degree of gasification of 80 to 99.5 percent) is within the range of 0.04 to 0.4 s. When the reacting substances' temperature rises to 2000 K the gasification time is shortened to 0.015 to 0.025 s. A time of about 0.2 s is required to reach a degree of gasification of approximately 99 percent for particles of an average size of 100 μm at a temperature of 1700 K.

The development of a technique for determining by means of calculations the specific expenditures of energy (Q_{sp}) for the conversion of coal is of considerable theoretical and practical interest. These expenditures are, of course, made up of expenditures of energy for heating the coal and oxidant and expenditures of energy for chemical reactions and, accordingly, represent the difference of the stagnation enthalpies of the working medium in the equilibrium (I_{equ}) and initial (I_{ini}) states, respectively. A method was suggested (by V. Ye. Messerle) for the computation of I_{ini} based on a thermodynamic calculation of the phase and chemical compositions of the products of the thermal conversion of the coal and of the oxidant with a process temperature higher than T_{ini}, because I_{ini} is a constant that does not depend on the temperature of the equilibrium thermodynamic system. It is possible to use as this base temperature when finding I_{ini}, in particular, the value of the temperature of the thermodynamic system at which stangation enthalpy I_{equ} passes through zero, changing from the region of negative values to the region of positive values. The technique for determining specific expenditures of energy in the plasma conversion of solid materials and the results of a thermodynamic calculation are presented in greater detail in [2].

As demonstrated by numerical experiments (Turgay Coal Field coal), with a carbon to oxygen ratio of 0.75 the gas phase (P = 1 atm and $1800 < T < 2000$ K) consists more than 99 percent of synthesis gas ($CO + H_2$) with a net caloric value of about 12,000 kJ/kg. The H_2 : CO ratio is 1.13 (H_2 = 53 percent and CO = 47 percent). It is characteristic that with T = 1800 K the oxidant (CO_2) concentration is less than one percent, and methane concentration less than 0.1 percent with $T > 1000$ K. An insignificant quantity of nitrogen oxide (about 7 ppm) is contained in the gasification products, which is several orders of magnitude less than in the flue gases. Oxides of sulfur are also practically absent (less than 0.1 ppm), but sulfur is present in various temperature ranges in the form of oxygen-free compounds: 1000 to 1875 K (H_2S), 1875 to 3950 K (CS) and 3950 to 5000 K (S).

In the temperature range of T = 1800 to 2000 K almost all the metallic iron in the condensed phase is combined with silicon and is represented by ferrosilicon (FeSi). Silicon carbide (SiC) and calcium sulfide (CaS) are also present and go into the gas phase with T equal to or greater than 2500 K. According to calculations, the remaining oxides of the mineral portion are reduced to the respective elements—Si, Al, Fe, Ga, Mg and Ti—with T equal to or greater than 3000 K (via various intermediate substances—SiO, Al_2O, Al_2S, etc.).[2]

Thus, it can be concluded from the results of theoretical calculation studies that an efficient power engineering process can be implemented in the process of the plasma gasification of coal under the conditions indicated above: the combined production of synthesis gas free of oxides of sulfur and nitrogen, and of valuable components from the mineral portion.

Experiments were conducted in models of plasma reactors specially designed for the thermal conversion of pulverized materials in a gaseous atmosphere. Their

principal difference from plasma chemical units consisting of a low-temperature plasma generator and a separate plasma reactor is the spatial integration in a single unit of the zone for the release of thermal energy and the zone for consuming it. This configuration makes it possible, on the one hand, to raise the unit's thermal efficiency to 70 percent (to 80 percent in the future) and, on the other, to intensify heat and mass transfer in the reaction space. For example, all the favorable properties of cyclone units and ore-smelting electric furnaces are used in the design of a cyclone-type plasma reactor, whose operating principle is based on the cyclone effect. The gaseous medium is introduced tangentially into the space of the reactor and picks up the solid pulverized material and swirls it in the high-temperature (discharge) zone, where heating and melting of the material and chemical reactions occur. The melt separates out on account of the cyclone effect and drains off along the wall and is then removed through a tap hole, and the gases are exhausted through nozzles located in the upper and lower sections of the reactor.

The operating principle of the plasma reactor in which the main series of experiments on the gasification of coal was conducted is based on the holding power of electric arcs (Sh. Sh. Ibrayev). A three-phase alternating-current arc forms in a cylindrical chamber between pencil electrodes and the body. An electromagnetic coil creates a longitudinal stationary magnetic field. Under the influence of the Lorentz force the arcs are displaced in the interelectrode gap, spanning the cross section of the high-temperature-zone chamber. During the movement of the arc columns, because of the difference between the aerodynamic drag at the wall and electrodes, the arcs expand and plasma flows originate in them in the direction toward the wall. The finely dispersed material with the gas reactant supplied to the electrode zone is picked up by the arc's plasma jets, is strongly heated and reacts, and the melt is thrown toward the chamber's walls. The cinders formed run off along the chamber's wall into the melt pool, where the melt is treated, and the synthesis gas is removed for further conversion. As Sh. Sh. Ibrayev's experiments have demonstrated, two-phase flows with a 10 to 15 proportion by weight of solid material and gas can be converted in such a reactor.

A sketch of the engineering unit developed for the thermochemical conversion of solid fuels based on a plasma reactor with electric-arc holding power is presented in fig 1. It should be mentioned that experiments were conducted in this unit[3] on the pyrolysis and gasification of high-sulfur coal with recovery of the mineral portion.

Material and heat flows were measured in the process of the experiments, as well as other parameters of the process necessary for knowing the material and heat balances. The following were recorded in particular: the rates of flow or consumption of coal (G_{ug}), steam (G_{par}), electrode graphite (G_{gr}), cinders (G_{sh}), flue gases (G_{og}), dust and sublimates (G_p); the electric power of the

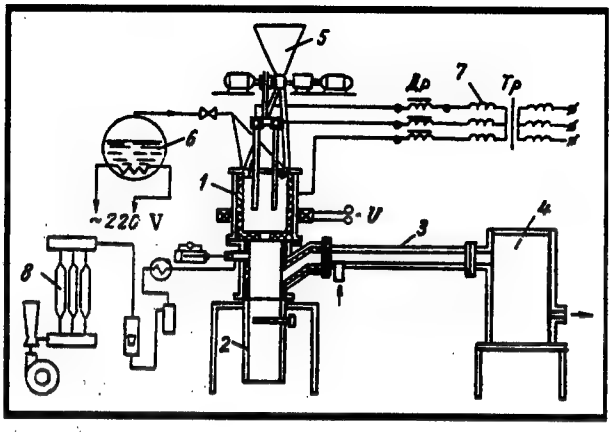

Figure 1. Experimental Engineering Unit for Plasma Conversion of Coal

Key: 1. Reactor 2. Cinder collector 3. Combustion chamber 4. Cooling chamber 5. Pulverized-coal feeder 6. Steam boiler 7. Electric power supply 8. Gas analysis system Tr—transformer; Dr—choke coil

reactor (W_o);the heat output introduced with the steam at T = 405 K (W_{par}); heat losses in various components of the unit—the reactor (W_r), gas and cinders separation chamber, synthesis gas oxidation chamber and cinder collector—as well as the removal of heat with the flue gases, etc.

Integral characteristics of the process were determined based on knowledge of the material (accurate within 4 to 5 percent) and heat (accurate within 10 to 12 percent) balances: the mass-mean temperature (T_{sr}), specific expenditures of energy $Q_{ud} = (W_o + W_{par} - W_r)/(G_{ug} + G_{gr} + G_{par} + G_g)$, the degree of gasification:

$$X_c = \left(C_{исх} - \sum_{i=1}^{n} C_{iкон}\right) \Big/ C_{исх}$$

(n is the number of samples of the condensed phase in the experiment), the degree of conversion of sulfur into the gas phase:

$$X_s = \left(S_{исх} - \sum_{i=1}^{n} S_{iкон}\right) \Big/ S_{исх},$$

and the concentration of synthesis gas (CO + H_2), and an X-ray phase analysis was also made of the solid residue.

Experimental data on integral characteristics of the gasification and pyrolysis process are presented in table 3. Turgay Coal Field lignite was used in experiments 1 to 6 and Podmoskovnyy Coal Field lignite in experiments 7 to 9.

It is obvious from the data in the table that the synthesis gas concentration reaches a considerable value and

Table 3. Characteristics of Process of Plasma Gasification and Pyrolysis of Coal

No. of exp.	Parameters					Gas phase composition			
	$\gamma=\frac{G_{пар}}{G_{уг}}$	$T_{ср}$, K	$Q_{уд}$, kW/kg	X_c, %	X_s, %	CO, % by vol.	H_2, % by vol.	N_2, % by vol.	H_2S, % by vol.
Pyrolysis									
1	0,125	2650	2,14	79,5	81,6	42,2	45,4	12,4	0,6
2	0,105	2775	2,39	84,1	78,6	47,0	42,2	9,8	0,55
3	0,135	3100	3,14	68,9	65,0	38,1	51	10,4	0,5
Gasification									
4	0,45	2600	2,48	76,9	83,8	21,8	60,7	12,7	0,7
5	0,89	2560	2,70	88,0	89,6	37,9	34,7	27,4	0,6
6	0,63	3100	3,85	90,5	92,2	34,4	40,8	24,8	0,5
7	0,2	2900	3,70	91,1	95,9	44,1	51,5	3,6	0,8
8	0,3	2400	2,63	91,45	96,7	40,0	55,6	3,6	0,8
9	0,36	2500	2,95	92,3	94,3	38,2	57,5	3,5	0,7

depends little on the operating conditions of the process (γ and T_{sr}). The influence of these conditions is noticeable to a greater extent in the degree of gasification (X_s) and the degree of the conversion of sulfur into the gas phase (X_S), but on the whole it is insignificant for the studied range of mass-mean temperatures and proportions (γ). Thus, the hypothesis has been confirmed experimentally that at a high temperature thermodynamic equlibrium is observed in the coal + oxidant system, which begins, according to calculated data, at T equal to or greater than 1800 K.

The higher value for the conversion of sulfur into the gas phase as compared with the degree of gasification of the coal, caused by the greater volatility (under the conditions of the experiment) of the coal's sulfur than its carbon, draws attention to itself. A certain unusual dependence of the gasification rate on the temperature is observed. For example, in experiments 1 and 3, with close values of characteristic γ, the value of X_s is 10 percent lower for T_{sr} = 3100 K than with T_{sr} = 2650 K. This is apparently explained by a reduction in the specific surface of the coal particles in a certain temperature range, which causes inhibition of the gasification reaction[4].

Let us also note that the gas phase of the coal conversion products does not contain oxidants and consists mainly of synthesis gas (CO + H_2). In terms of the ratio of hydrogen to carbon monoxide, the gas produced meets the requirements for reducing gases for metallurgical processes, because the hydrogen concentration is higher than 50 percent and the carbon monoxide concentration is 30 to 40 percent. And it is easier and less expensive to clean oxygen-free compounds of sulfur than to clean oxides of sulfur from gases.

The results of an x-ray phase analysis of the condensed phase of both the pyrolysis process and gasification showed that silicon carbide (SiC) and ferrosilicons (FeSi, $FeSi_2$, Fe_5Si_3) are present in the cinders, and these compounds can be used as energy-storing substances. Reducing material in the form of metallic shot 1 to 8 mm in diameter uniformly scattered in the cinder portion is contained in the cinders together with amorphous material and crystalline cinder-forming components. The majority of it has magnetic properties, but nonmagnetic shot is also encountered. The content of magnetic ferrosilicon, separated by means of a permanent magnet, in the cinders reaches 26 to 30 percent.

Products of the reduction of mineral components of the coal were not detected in sublimates. This is apparently due to the fact that reduction processes are not able to be noticeably realized when the coal particles remain in the reaction chamber for a relatively short time (approximately 10^{-2} s). The fact that elemental silicon is present in the sublimates together with an amorphous phase with mass-mean temperatures in the reactor of higher than 2600 to 2800 K speaks in favor of this hypothesis. According to the results of a quantitative x-ray phase analysis, its concentration in condensed products varies over the range of 1.5 to 9 percent.

Let us compare the composition of the gas phase measured in the experiments with the results of thermodynamic calculations (table 4) with identical (in the experiment and calculation) specific expenditures of energy. Rather good agreement is observed between the calculated and measured compositions of the gas phase, which attests to the closeness of the compositions of gaseous products of both pyrolysis and gasification to the point

of thermodynamic equilibrium. Thus, the results of direct experiments confirm the technical implementability and feasibility of the total power engineering conversion of low-grade coal by using a plasma. This approach makes it possible to unite the problems of economizing on raw materials, environmental protection and energy and metal conservation and, accordingly, is a quite timely trend of present-day power engineering.

Table 4. Comparison of Results of Experiment and Calculation

Components, vol.%	Pyrolysis				Gasification			
	Exp. 1 (T=2650 K)		Exp. 2 (T=2775 K)		Exp.6 (T=3100 K)		Exp. 4 (T=2600 K)	
	Exp.	Calc.	Exp.	Calc.	Exp.	Calc.	Exp.	Calc.
CO	42.2	45.0	47.0	48.6	34.4	35.5	21.8	23.1
H_2	45.4	46.0	42.2	43.8	40.8	22.0	60.7	60.9
N_2	12.4	7.8	9.8	6.0	24.8	9.6	12.7	12.0

Plasma Ignition and Stabilization of Burning of Pulverized Coal Flame

The essence of the method of plasma ignition and of stabilization of the burning of low-grade coal consists in heating the air-and-coal mixture to a temperature at which the most complete separation of volatile components is achieved and partial gasification of the remaining coke is accomplished so that the total yield of fuel gas will be on the level of the yield of volatile components from high-reaction coal in the process of its direct burning. In other words, the method suggested can be regarded as a method of producing from low-grade coal a two-component (fuel gas and remaining coke) high-reaction power-generating fuel that can be used for the ignition and stabilization of the burning of a pulverized-coal flame in a steam power plant.

As an experiment has demonstrated, the ignition and burning of a pulverized coal mixture are accomplished without particular difficulty for power-generating coal with a yield of volatile components of greater than 25 percent. Therefore, in the method of the plasma activation of coal it is possible to limit oneself to a total yield of fuel gases at the level of 30 percent.

Tests were conducted, on KazNIIenergetika's large-scale flame test bed, of power-generating coals widely used in the industry—Kansk-Achinsk (KAU), Ekibastuz (EU) and improved-quality Donets anthracite culm (ASh)—in order to verify the effectiveness of plasma ignition and stabilization of the burning of low-reaction coal. The apparatus was a vertical cylindrical furnace 7.5 m high with an inside diameter of 1.6 m^5. The burner being studied was installed in the upper section with a plasma generator and the supplying of the air-and-coal mixture and secondary air. The maximum output of the pulverized-coal feeder was 500 kg/h. The plasma generator received its electric power from a 380 V industrial-frequency line via a transformer and rectifier.

Tests were conducted on a two-scroll burner with plasma generators of several types, ring-type, two-electrode and single-electrode, as well as on a muffle burner with a plasma primary furnace. In all these cases a high-reaction two-component fuel that stabilizes the burning of the main stream of the air-and-cold mixture was obtained in the outlet of the thermochemical preparation unit with a plasma source.

The characteristics of the coals studied are presented in table 5, and the operating conditions of the experiments, in table 6.

Table 5. Heat Engineering Characteristics of Coals, wt.%

Type of coal	W^a	A^a	V^a	C^a	H^a	N^a	S^a	O^a	Q^n_w(kcal/kg)
KAU	1.30	12.8	44.9	60.15	4.64	0.77	0.77	20.86	4920
EU	1.28	44.2	16.70	47.5	2.2	0.8	0.55	6.84	3815
ASh	1.13	36.0	6.8	55.5	1.7	0.43	0.80	5.26	3990

Table 6. Operating Conditions of Experiment

Type of coal	Remainder in sieve, R_{90}, %	Rate of flow of coal through burner, kg/h	Rate of flow of coal through plasma generator, kg/h	Concentration of coal dust in coal-and-air mixture, $\mu = G_{ug}/G_g$	Electric power of plasma generator, kW	Ratio of electric power to thermal power of burner, ε_{el}, %
KAU	30	400	80-90	1.1-1.3	15-17	0.6-0.8
EU	18	300-450	60-120	1.2-2.5	15-36	1.0-1.8
ASh	4	300-360	60-70	1.2-1.5	20-32	1.2-1.9

Stable favorable indicators of the process of plasma ignition and stabilization of burning for all the coals were arrived at as the result of test bed tests. Moreover, it is possible to achieve the ignition of KAU from the cold state of the furnace (T_{top} = 40° C) practically instanteously with a lag on the order of 0.5 s with a relatively small electric power contribution, ε = 0.6 to 0.8 percent (table 6). The plasma generator was switched off after two minutes and stable burning of the flame was observed.

In the process of the plasma ignition of EU from the cold state of the furnace space (T_{top} = 30° C), with the supplying of 60 kg/h of coal to the plasma generator and a final rate of flow of the main pulverized-coal flow of 240 kg/h, ignition of the flame was achieved, and after three to five minutes of operation of the plasma generator the temperature in the flame interior reached 1420 degrees C, after which the furnace reached stationary thermal conditions and operated stably.

The possibility of the stable burning of KAU, EU and ASh air-and-coal mixtures without intensification with fuel oil, with moderate expenditures of energy in the range of ε_{el} = 0.6 to 1.9 percent (table 6), was confirmed by test bed studies of the plasma stabilization of the burning of low-grade coal. A rise in temperature in the flame interior of by 150 to 180 degrees was achieved here for EU, and of by 100 to 120 degrees C for ASh. The maximum temperatures in the flame interior, measured by means of a water-cooled probe, equaled 1500 to 1600 degrees C for EU and 1500 to 1520 degrees C for ASh. The unburned carbon was reduced in the process from 3.5 to 1.3 percent for EU and from 15 to 5 percent for ASh with specific expenditures of energy of 0.1 to 0.5 kW/kg of coal, respectively.

A 15- to 20-percent reduction in the yield of oxides of nitrogen as compared with the burning of a flame without a plasma generator was also recorded in the experiments. This is apparently explained by the implementation in the method described of a two-stage scheme for organizing the burning of solid fuel, making possible a reduced yield of oxides of nitrogen. In the experiments fuel was supplied to the plasma activation unit with α_v = 0.1 and to the burner with α_v = 1.1 (where α_v is the excess air). Let us also note that the taking of samples of fly ash and subsequent microphotometric measurements of them revealed definite differences in the granulometric distribution and shape of ash particles with the plasma generator working and turned off. In particular, whereas with the plasma generator turned off the ash particles are angular with sharp projections, with the plasma generator operating they have a round shape without sharp projections and noticeably smaller dimensions (by almost an order of magnitude).

Thus, the set of theoretical and test bed studies shows that the use of a plasma for activation of the burning of low-grade fuels, besides a saving of fuel oil, can make possible a significant reduction in unburned carbon and yield of oxides of nitrogen. In addition, with the broad use of the plasma method for the activation of burning it is possible to convert a pulverized-coal-fired steam power plant to a single kind of fuel: coal.

It was revealed by a calculation of the economic efficiency of replacing atomizing burners at steam power plants by a plasma ignition system, for various regions of the country and types of pulverized-coal-fired furnaces, that the saving from the replacement of one ton fuel-equivalent of fuel oil by solid fuel and electric power equals 4 to 6 rubles per ton fuel-equivalent in the Central European section of the country, 5 to 7 in Central and Northeast Kazakhstan, 6 to 8 in West Siberia, and 8 to 10 rubles per ton fuel-equivalent in Krasnoyarsk Kray[7]. For instance, the estimate for the conditions of Kazakhstan as applied to a 300-MW power-generating unit gives a saving of about 500,000 rubles a year, and the use of plasma for activation of the burning of Donets ASh for a boiler of the TP-100 type provides an annual saving of more than 150,000 rubles.

According to an estimate by American and Canadian specialists (the Babcock - Wilcox and Sandvik - Normins) firms), the cost of operating and servicing plasma generators equals 28 percent of the cost of an ignition system using fuel oil[6].

Thus, a set of conducted theoretical-scientific, experimental and test bed studies has revealed the promise, technical implementability and economic feasibility of using a plasma in power engineering for increasing the efficiency of the use of low-grade fuels.

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UDC 621.472:522.58

Method of Bench-Mark Vectors in Optics of Solar-Energy Concentrating Systems

18610243 Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSE: SERIYA FIZIKO-TEKHNICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, Jan 88 (manuscript received 31 Mar 87) pp 81-84

[Article by E. Annaberdyyev, Scientific-Industrial Association "Solntse" (Sun), TuSSR Academy of Sciences]

[Abstract] Movable bench-mark vectors are constructed for description and design of solar-energy concentrating systems, such systems consisting essentially of mirrors and heliostats. An orthonormal triad of bench-mark vectors is constructed for unit vestors, of the following important characteristics of a heliostat system: incident rays, reflected rays, sighting directions, bisectrices, and the normal to a heliostat. The obtained bench-marks will facilitate description of losses due to mutual blocking, shading and misdirection of heliostats over a day. Figures 1; references 2: 1 Russian, 1 Western (in Russian translation).

UDC 621.22-156:621.757+621.791

Assembly and Welding of Runner for Mixed-Flow Turbine in Verkhne-Teriberka Hydroelectric Power Plant

18610174 Moscow ENERGOMASHINOSTROYENIYE in Russian No 1, Jan 88 pp 38-40

[Article by V. S. Boriskin, engineer]

[Abstract] A heating facility has bene built and installed at the Syzran Turbine Manufacturing Plan for assembly and welding of the runner for a mixed-flow turbine in the Verkhne-Teriberka Hydroelectric Power Plant. This runner, made of 06Cr12Ni3Cu corrosion-resistant steel, requires preheating to 150-300°C and maintaining the heat during assembly. Its smallest diameter is 2000 mm and its largest diameter is 6800 mm, which the heating facility is designed to accommodate. The facility has a power rating of 1280 kVA, 320 kVA per phase, and operates from a 380 V - 50 Hz line. It consists of four panels designed for radiative heating of the runner to 150-200°C at a rate adjustable over the 20-50°/h range. The temperature of the heater elements is 750°C, at which they draw a power of 15 kW each. The voltage across each element is 45 V and the current can be varied up to 350 A. The facility requires 10 m^3/h of water for cooling, weighs 25 tons without runner, and occupies a 200 m^2 floor area. The runner assembly proceeds in two stages, welding of all the 15 blades to the upper hub with subsequent heat treatment and machining followed by their welding to the lower hub with subsequent heat treatment and final machining. The welding seams and fillets are inspected ultrasonically, after having been finish ground. The turbine with the runner thus assembled operates now with 94.3 percent efficiency under favorable conditions. Figures 3; tables 1.

UDC 621.165+621.438

On Use of Reaction Turbines and Congruent Blading

18610055 Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 8, Aug 88 (manuscript received 6 Jan 88) pp 76-83

[Article by Candidate of Technical Sciences, Docent G. M. Kochetov]

[Excerpts] The problem of using turbines with reactive blading is considered. Individual problems of the theory of the congruent stage are refined. A formula is found for determination of the degree of reactivity, which can be used to construct the optimal congruent stage.

The production of reactive steam and gas turbines, including those with congruent blading, is now an urgent problem for USSR turbine building, since conservation of energy resources is acquiring ever greater significance with each year. These turbines, usually manufactured with a drum-type rotor at our turbine-building plants, unlike foreign companies, are now essentially not manufactured. The existence of congruent stages is not mentioned in the literature on turbines for the past 10-15 years. Thus, for example, whereas several pages for this material is devoted to steam turbines in the third edition of Professor A. V. Shcheglyayev's textbook[1] and even an example of calculating a reactive turbine with congruent profiles is placed in the textbook, this materials is completely omitted in the fourth edition[2].

When stages with degree of reactivity of approximately 0.5 are produced as a result of optimization calculation, it is desirable to use congruent blading as the most efficient. It should also be noted that there are presently no clear criteria, on the basis of which optimization calculations of turbines should be made. In the author's opinion, these calculations should begin with optimization of the general indicators of the turbine and of the turbine plant (number of turbine stages[3], number of heaters and so on) and should end with optimization of the configuration and characteristics of each of the stages. All the turbine stages can be produced with different profiles during stage optimization, which considerably complicates and increases the cost of production. Calculations of different levels should apparently be arranged by the sequential approximation method to correct these optimization outlays. Similar developments present an independent problem.

All countries of the world have organized a struggle for conservation of energy resources. The consumption of energy resources increased by only 8 percent in Japan from 1973 through 1985, while the gross national product doubled during this time. There is no interest among our turbine-building associations in developing turbines with reactive blading, which are more economical at significant capacities than turbines with diaphragm-type stages.

The problem of increasing the efficiency of turbine plants should be solved in an integrated manner, rather than by parts. But no one is responsible for solution of these problems, although Gosplan should be rightfully among the first rank of interested personnel in conservation of fuel resources, which reactive turbines promise. Economic incentives should be worked out immediately and the economic mechanism in the country's fuel-energy complex should be changed so as to turn to output of more economical energy equipment, also required for energy-conserving technologies.

We have either forgotten or have not paid attention to the advantages of reactive turbines with congruent blading. And these advantages are very significant. A number of well-known foreign companies are incapable of making the cylinders of high- and medium-pressure steam turbines reactive, while diaphragm-type low-pressure cylinders (TsND), although in many cases low-pressure cylinders are also made reactive. These turbines are manufactured in Japan, West Germany, the United States, Switzerland and other countries. There is a typical principle: medium- and high-power turbines are mainly made reactive, which require considerable quantities of fossil fuel in steam generation. The higher conservation of these turbines, compared to active turbines, reduction of the fossil fuel reserves and reduction of its cost are all economic prerequisites which determined the preference given to reactive blading in most countries with developed power engineering.

Active and reactive turbines were considered approximately equal in economy before the appearance of units with rating of 100 MW, although the relative blade efficiency of reactive stages is higher due to lower speeds, but leaks through the radial clearances in the case of short blades destroy this advantage. If a turbine with sufficiently high blades can be developed and if the radial clearances can be thoroughly sealed, then the advantage of reactive stages becomes indisputable.

The use of the active principle has undoubted advantages over the reactive principle only at low volumetric admissions of steam and nozzle steam distribution. The boundary where reactive blading becomes more feasible has not been defined clearly. This is a technical and economic problem which is solved by the designer in each specific case.

The disadvantages of congruent blading are insignificant. They should include the impossibility of partial delivery of the working body and the fact that the axial dimensions of the flow-through part of a multistage reactive turbine may be greater at low initial parameters than those of an active turbine. The somewhat higher cost of these turbines also may not be related to serious

deficiencies according to advanced concepts. It turns out that the advantages of turbines with congruent blading are considerably higher than the disadvantages, while their higher economy in many cases advances them to the forefront. Therefore, the absence of no manufacture of reactive turbines in the USSR and of the orientation of our turbine building only toward active (diaphragm) turbines seemingly legalizes the annual overconsumption of fuel of several million tons not only today but on even larger scales in the future. Since any data on these types of turbines have bene excised from our latest textbooks on turbines, those who will solve the problem of fuel conservation will inevitably have difficulties.

It should be emphasized that theory and practice with respect to congruent blading need further development, since much requires serious refinement and correction both in interpretation of the thermal process and in the method of calculation of this blading.

Many foreign companies are now working to improve congruent blading. Turbines with this blading for new supercritical initial steam parameters are now being designed in some countries. Thus, for example, the Power Research Institute in the United States has organized studies on the program of selecting the profile of the equipment of new electric power plants operated on coal[8]. Detail design of a reactive turbine with capacity of 700 MW having initial steam parameters of 31 MPa, 593/593/593°C was begun in 1985. Similar studies have been extensively developed by Japanese companies.

It should be noted that the combination for superpowerful steam turbines of the congruent flow-through part with vortex steam inlet is very promising[9]. Reactive blading is finding ever broader application in worldwide power engineering as the most promising. And these trends may not be disregarded in the plans of development of our turbine building.

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Advanced Methods of Protecting Metals Against Corrosion

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 10, Oct 88 pp 29-32

[Article by M. Svoboda, State Protection of Materials Against Corrosion Scientific Research Institute imeni G. V. Akimova, Prague, CSSR]

[Text] Most metals exist in nature in the form of chemical compounds (oxides, sulfides, sulfates, carbonates, silicates, chlorides, etc.). Only some metals, for example, platinum and gold, exist in the form of compounds, and their elemental form is not stable from a thermodynamic standpoint. This applies primarily to all metals used in technology. The breakdown of these metals under the effect of the natural environment (the atmosphere, freshwater, and seawater) or technological media (aqueous solutions of salts, acids, and other chemical compounds; a gaseous medium; etc.) is a natural process since the corrosion process transforms metals from their thermodynamically unstable form into stable naturally existing compounds of these metals. During atmospheric corrosion, the compounds are transformed on account of the reaction of the metals with the oxygen in air and water as well as by those atmospheric components that end up in the atmosphere due to emissions from industrial enterprises, for example, sulfur and nitrogen oxides and other chemical compounds characteristic of this sector of industry. The atmosphere near the sea contains an aerosol of sea salts that primarily contains sodium chloride.

Random processes transform metals from their thermodynamically unstable form into stable compounds, i.e., corrosion processes inflict an estimated 15 billion koruna's worth of damage to the CSSR's economy yearly. Based on analyses conducted in different countries throughout the world in the past few years, corrosion losses may be reduced significantly simply by introducing existing scientific and technical knowledge into practice.

In the socialist countries, the theoretical bases of protecting metals against corrosion are being developed, and applications work is being conducted within the framework of the CEMA's problem "Developing Measures To Protect Metals Against Corrosion." Its nine themes (development of theoretical foundations; study of the corrosion resistance of alloyed alloys and protective methods and means; methods of applying and studying the properties of organic, galvanic, metal, and enamel coatings; methods of electrochemical protection; protection against atmospheric corrosion; corrosion inhibitors; and protection of concrete and reinforced concrete against corrosion) include several dozen individual specific assignments. The results of joint scientific-technical developments and the direction of further works were discussed at conferences (the first was held in Moscow in 1971, the second in Prague in 1975, the third in Warsaw in 1980, and the fourth in Varna in 1985, with the fifth one slated for the GDR in 1990). Based on the materials from the conference held in Varna in 1985, a four-volume collection was published. It presents the achievements of the socialist countries in the field of protecting metals against corrosion during the past 5 years.

The Delegates' Council (consisting of one representative of each of the participating socialist countries) was charged with managing CEMA problem "Development of Measures To Protect Metals Against Corrosion." A scientific-technical council (consisting of two representatives from each country) is the consultative organ of the Delegates' Council. The coordination center is located in Moscow in affiliation with the All-Union Protection of Metals Against Corrosion Interbranch Scientific Research Institute.

CSSR specialists in the field of protecting metals against corrosion are currently working on ensuring the durability of all parts of production equipment, machines, and metal products while simultaneously reducing expenditures of materials, labor, and power and satisfying ecological requirements while conducting their anticorrosion measures.

A high quality of protecting products against corrosion can sharply increase their competitiveness on the world market. As an example, one can cite the Shkoda automobile, whose corrosion resistance has been increased thanks to the introduction of modern developments. This increase in corrosion resistance has helped increase the demand for this car both in the CSSR and abroad.

When developing and implementing measures to protect metals against corrosion in actual practice, we must strive to have the service life of the corrosion protection coincide with that of the physical life of the specific product, machine, or structure being protected or with the period before it becomes obsolete. Such a path frequently leads to the transference of the implementation of complete and high-quality corrosion protection to the production sphere. Everyday practice graphically shows that, in many cases, the user must do a great deal to obtain the required corrosion protection even though he has neither the appropriate equipment or technical knowledge and media. The view that all of this will result in an increase in the corrosion protection costs incurred by the manufacturing enterprise is not justified from the standpoint of societal expenditures on corrosion protection since the cost of containing equipment and renovating low-quality corrosion protection performed by the manufacturing enterprise during the life of a machine or piece of equipment is many times greater than is the cost of initial high-quality corrosion protection. The increased costs of the manufacturing enterprise may be compensated by introducing mechanization and automation when protective coatings are applied. For example, the costs of manually applying aluminum coatings by spraying (metallizing) to protect steel structures are four- to fivefold higher than when the same coating (but with a higher quality) is applied on an automated line.

Labor productivity during the application of protective coatings and the coatings' service lives may be increased by using processes based on new principles. In the CSSR, these are primarily vacuum and plasma technologies, the technology of applying protective aluminum coatings by the electrometallization method, and the technology of applying galvanic coatings and glass enamels. Attention is not only being paid to developing the technology and controlling the properties of coatings but also to ecological and economic matters. Using robots and manipulators in automated lines to apply organic coatings is considered very important.

In the field of vacuum processes of applying protective metal coatings, the development of new technologies is being based on the experience that has accrued in the operation of automated lines, for example, lines for applying metal coatings onto springs, which was introduced in the late 1980's as a result of the joint work of a collective of associates from the national enterprise Perovna Gostivarzh (the line was introduced at this enterprise) and at the Institute imeni G. V. Akimov. The aforementioned process is classical from today's viewpoint. The process makes it possible to apply coatings made solely of metals. The technology cannot be used to apply coatings based on metal compounds with nonmetallic elements. New developments in the field of vacuum technology make it possible to apply coatings based on nitrides, carbides, or oxides of titanium, tungsten, niobium, and chrome. The development of vacuum processes is also linked to the fact that this type of coating cannot always be produced on the basis of another technology. Also fundamentally important is the fact that the process conforms to economic requirements.

Glass enamels have long been known to mankind. This type of coating is encountered on ancient decorations. Later they were used widely and are still being used today in manufacturing household products, primarily domestic tableware. The chemical, food, and pharmaceutical industries have equipment with enamel coatings that are resistant to different media.

In the past few years, glass enamels have made it possible to significantly increase the service life of components and assemblies of power-generating units such as steel smokestacks, air heater inserts for electric power plant boilers, etc. Using enamel coatings has increased the inserts' lives four- to sevenfold. About 200,000 m^2 of inserts have been coated with enamels. The use of enamels to protect large tanks used in agriculture (silo towers, tanks for wastes and fertilizer solutions, equipment to clean wastewaters) is also noteworthy. The concern Vitkovitse manufactures all of these. Bilayer enamel coatings are used for long-term protection. The development and introduction of single-layer coatings are very important from economical and technical standpoints.

The new technology for applying enamel coatings is based on using powdered frit (in accordance with the classic technology, frits are applied in the form of aqueous suspensions by using sprayers in a high-voltage electrostatic field). This advanced technology was developed in the past five-year-plan by a collective of workers from several scientific research institutes and industrial enterprises and was introduced at the plants of the concern Stroysmalt on fully automated lines that were created simultaneously with the technology. The license for this technology has been sold abroad.

The technology for applying aluminum protective coatings by spraying (metallization) is used in the CSSR for the long-term protection of steel structures, for example, steel tube supports for electrifying railroad transport and cars for coal mines. The life of an aluminum coating, either used alone or in conjunction with a paint coating (a combined coating) is commensurate with the physical life of the steel structure or piece of equipment or with the period before they become obsolete. The advantage of an aluminum coating applied by metallization is confirmed by the fact that the life of paint coatings in an aggressive industrial atmosphere ranges from 2 to 5 years depending on the type of coating and the quality with which it is applied. The existing view that scarce and expensive aluminum is used to manufacture the coating is easily disputed by the fact that paint coatings also contain nonferrous metals in the form of very diverse compounds. A paint system consisting of two layers of ground coat based on red lead and drying oil combined with two layers of pigment finish and applied onto a sandblasted steel surface or a surface prepared by the process of etching guarantees relatively good corrosion protection. The life of such a coating is no less than that of an aluminum coating with one layer of alkyd enamel. About 200 g lead in the form of orthoplumbate (red lead) per square meter of painted surface is expended when this type of paint coating is used.

The AD2 manual wire gas-plasma gun was developed to apply aluminum coatings by hand, which, though labor intensive and expensive, is nevertheless the only method possible in certain cases. It is manufactured by the national enterprise Kovofinish.

Fully automated lines for metallization were created approximately 20 years ago. The process has proved itself in industrial practice. Expenditures to apply coatings on a metallization line are comparable to those required for organic paint coating. The life of a paint coating is largely dependent on the surface preparation of the metal before painting. Sandblasting or shot-blast cleaning are the most suitable methods of preparing a steel surface before painting. However, since these methods are not inexpensive, it is more rational to apply an aluminum coating to such surfaces rather than a paint coating. The lack of an enterprise to manufacture integrated metallization automated lines is the main obstacle to the wide-scale introduction of metallization on automated lines. The CSSR has the prerequisites for creating the capability of developing specific plans to the user's specifications and guaranteeing the delivery of the integrated automated equipment for a "turnkey" line.

Metallization technology is suitable for applying not only aluminum but other metals as well. It is therefore possible to introduce this method in different sectors of the national economy, for example, metallization to repair worn components of machinery and equipment.

The technology of plasma spraying protective coatings makes it possible to apply coatings of materials having a high melting point such as oxides of metals and a number of compounds including ceramic and cermet materials onto the surface of large products. A plasma gun (burner) with water stabilization has been created in the CSSR, and an industrial-type unit has been developed.

Work on this problem is currently underway at the Plasma Physics Institute of the CSSR Academy of Sciences. Plasma units for use in industry have been developed, and problems related with creating fully automated industrial lines for wide-scale introduction into the national economy have been solved in cooperation with enterprises of the ZEZ (electrothermal installation plants).

In the area of applying protective coatings, processes based on using lasers and the principles of implanting ions into the surface of metals and alloys are completely new and have not yet been used in industry on a wide scale. Existing laboratory experience shows that when powdered material applied to a product's surface has been laser treated the material becomes fused, with the resultant coating being fixed onto the surface being protected thanks to diffusion. Fusible material to create a surface having the required quality does not have to be used in powder form. It is, for example, technically feasible to use a laser to fuse galvanic coatings that are also fixed onto the metal's surface thanks to diffusion. Other versions of this promising process, which is one of the new, advanced technologies, are also being examined.

The process of implanting ions into a metal surface makes it possible to produce a layer on the surface of a product manufactured from inexpensive material such as carbide steel that is analogous to expensive and scarce alloys from the standpoint of corrosion resistance.

Organic paint coatings are mainly used to protect machine building products and steel structures from atmospheric corrosion and the effect of fresh water and seawater. It was not very long ago that anticorrosion paint ground coats contained toxic compounds of titanium and hexavalent chromium. New nontoxic anticorrosion pigments based on iron oxide, titanium oxide, and zinc phosphate that have been developed during the past five-year-plan and are being manufactured by one of the chemical plants make it possible to produce nontoxic anticorrosion dyes for priming a steel surface.

Pneumatic spraying is the principal method used to apply paint coatings in the CSSR's machine building plants. To reduce the toxicity of paint materials, toxic pigments are replaced by nontoxic ones, paint materials with water instead of organic solvents are being created, and powder materials are being used increasingly widely.

At the present time, the only way of solving the ecological and technical-economic problems existing in the field of applying paint coatings is to use fully automated lines equipped with robots and manipulators.

Automated painting lines equipped with reliably operating manipulators have been developed and introduced thanks to the joint work of scientific research institutes and enterprises manufacturing the respective equipment and user enterprises. Thus, two lines for applying paint and powdered coatings were introduced at an enterprise that manufactures buses.

Associates of the Protection of Materials Against Corrosion State Scientific Research Institute imeni G. V. Akimov, working jointly with scientific research and production organizations in the CSSR and other socialist countries, primarily the USSR, are taking part in the development of individual problems included in the Integrated Program for Scientific-Technical Progress of the CEMA Member Countries up to the Year 2000.

UDC 669.13.018.256

Technological Aspects of Producing Wear-Resistant Castings of C.I.Cr9Ni5 Alloy Cast Iron

18610113 Moscow ENERGOMASHINOSTROYENIYE in Russian No 9, Sep 88 pp 26-32

[Article by A. I. Belyakov, candidate of technical sciences, V. I. Kulikov, candidate of technical sciences, and N. S. Gushchin, engineer]

[Abstract] Accelerated construction of thermal electric power plants operating with solid fuel such as high-ash coal from the Ekibastuz basin has been scheduled for the 1986-2000 period so as to ensure adequate economic growth and social development, operation of all thermal electric power plants in the current year already requiring pulverization of so much coal (350 million tons, about half the total output of the coal mining industry) that construction of modern pulverizers with a manufacturing license from Deutsche Babcock AG is being undertaken. These pulverizers feature a high degree of automation and a 12,000-16,000 h long service life with a low rate of metal wear within the 12-29 g/ton range, also high stability owing to original design of the working parts. These parts are made abroad of Nihard-4 alloy cast iron. At the Belgorod Power Machinery Manufacturing Plant, where the recommended technology is not available, wear-resistant castings of C.I.Cr9Ni5 alloy cast iron are produced for rolls of MPS-2650 medium-stroke pulverizers processing coal at a rate of 80 tons/h. In order to meet the requirements for Deutsche Babcock

pulverizers, it has been necessary to refine the casting process and the subsequent heat treatment, which includes normalizing, so as to ensure adequate mechanical characteristics with a minimum of gaseous inclusions (N_2,O_2) in thick sections. This was achieved on the basis of an experimental study which included macrostructural examination for shrinkage, microstructural examination for distribution of alloying elements and residual stresses, also mechanical testing for Rockwell C hardness and for wear by electrocorundum. Inspection of a pulverizer operating in the Chaykovskaya TETs indicates a satisfactory performance of this machine and a high reliability of its parts made of C.I.Cr9Ni5 alloy cast iron. Figures 8; tables 6; references 2: 1 Russian, 1 Western.

UDC 629.12.011

Stressed and Strained State of Shafting on Deformable Base

18610408b Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 3, Mar 88 (manuscript received 23 Jun 87) pp 29-35

[Article by V. I. Sutyrin, engineer]

[Abstract] A numerical stress and strain analysis of shafting on ships is shown, calculations taking into account deformability of the ship hull under external loads. The algorithm, based on the finite elements method involves recursion of stiffness matrix coefficients and the load vectors for components of the discrete model to cross-sections at successive nodes through the engine room. It also includes calculation of bearing displacements under the static shaft load during assembly, which eliminates the need for calculating shaft deflections during operation. The engine on a foundation, the intermediate shaft, propeller shaft, and deadweight are assumed located in this engine room. The calculations proceed in three stages, all components other than the shafting being eliminated in the second stage so that only the generalized stiffness matrix and load vector of the shafting remain to be evaluated in the third stage. The procedure is demonstrated on the shafting for a propeller screw weighing 11,100 kg in a transport ship with a 152 m long and 22.2 m wide hull having the usual cross-sectional layout and a board height of 13.6 m. Figures 2; references 7: Russian.

UDC 621.3.019.3:621.391

Measuring Parameters of Cracks in Engineering Structures During Tests

18610408a IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 3, Mar 88 (manuscript received 15 Apr 87) pp 20-24

[Article by N. F. Bocharov, doctor of technical sciences, professor, N. G. Fedotov, candidate of technical sciences, docent, and M. I. Kurbatskiy, candidate of technical sciences]

[Abstract] A readily automated method of measuring the parameters of cracks in engineering structures during reliability tests is proposed, such measurements being necessary in addition to direct visual inspection. The necessary invariance of readings with respect to crack location and crack orientation cannot be achieved by direct decoding of television images, but is attainable by using the probability of geometrical events. The method involves finding the points where the image of the crack intersects a randomly-oriented set of straight line segments of equal length. A function describing the number of lines of a given length and orientation that include at least one such point is then integrated over the area of the crack image on a video screen. The algorithm is shown to be variant of the Monte Carlo method, a sufficiently large number of these intersections being required for adequate accuracy. With 1000 randomly-oriented lines, the estimate of geometrical probability has an r.m.s. deviation of $1.6.10^{-2}$ and a dispersion of $0.25.10^{-3}$. The equipment for such measurements includes a light source, a negative of the crack image on a photographic plate, an optical filter with transparent randomly-oriented line segments of fixed length on an opaque background, an objective lens, and a vidicon with sweep and screen. Video pulses pass through AND-logic and then two counters which feed data to two computers for calculating the rates of change of crack length and crack area respectively. Figures 1; references 4: Russian.

UDC 539.3

Stability of Conical Shells in Relation to Their State of Stress and Strain

18610267b Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 5, May 88 (manuscript received 13 Mar 86) pp 60-64

[Article by N. V. Kovalchuk, Ukrainian Scientific Research Institute of Steel Structures Design, USSR State Committee for Construction, Kiev, and N. A. Solovey, Kiev Institute of Construction Engineering]

[Abstract] Axial compression of conical shells is considered, their state of stress and strain being calculated by the method of finite elements in the geometrically nonlinear formulation of the problem for a stability analysis and particularly dependence on the cone angle. A perforated frustum of a conical shell is compared with an unperforated one, each being either smooth or reinforced by hoops and stringers. Numerical results indicate payoff of reinforcing a perrated conical shell is much larger than that of reinforcing an unperforated one. Figures 4; tables 1; references 15: Russian.

UDC 539.4

Dependence of Distribution of Self-Balanced Stresses in Structure of Multilayer Composite Material on Form of Small-Scale Local Bends With Phase Reversal From Layer to Layer

18610118a Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 7, Jul 88 (manuscript received 25 Nov 87) pp 30-37

[Article by S. D. Akbarov, Institute of Mathematics and Mechanics, AzSSR Academy of Sciences]

[Abstract] The effect of small-scale local bends in the structure of a multilayer composite material on the distribution of self-balanced stresses in it is analyzed for

dependence of this distribution on the form of those bends. The filler is assumed to consist of infinitely many equally thick layers identically bent along the same normal axis but with phase reversal from layer to layer. In accordance with the model of a piecewise-homogeneous body under a normal load which does not produce significant shearing stresses, the plane state of strain and the distribution of normal stresses are calculated in the Neuber-Papkovich representation with the aid of Fourier transforms. Numerical solution of the applicable equations with variation of the two parameters characterizing the waveform of bends has been programmed in FORTRAN-4 language for the BESM-6 high-speed computer at the Institute of Cybernetics at the AzSSR Academy of Sciences. Figures 5; tables 4; references 9: Russian.

UDC 539.3:534.1

Nonaxisymmetric Free Vibrations of Thick-Walled Nonhomogeneous Transversely Isotropic Shallow Spherical Shell
18610267a Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 5, May 88 (manuscript received 4 Jul 86) pp 12-17

[Article by N. A. Shulga, A. Ya. Grigorenko and T. L. Yefimova, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Free vibrations of a thick-walled transversely isotropic shallow spherical shell, nonaxisymmetric in the case of a nonhomogeneous shell, are analyzed for dependence of their frequency spectrum on geometrical and physical parameters of such a structure. The problem is formulated in a spherical system of coordinates, the corresponding equations of motion and of Hooke's law with Cauchy relations taken into account then being solved for a shell which has a piecewise inhomogeneity in the form of a discontinuity with contact boundary conditions. The solution is obtained in Legendre polynomials and the trend of branches in the frequency spectrum is found to depend on the order of the corresponding one, this dependence being strong and nonmonotonic for class-II vibrations and piecewise almost linear for class-I vibrations. Figures 2; references 5: 4 Russian, 1 Western.

UDC 533.6.013.42

Deformation of Spherical Shell by Pulse of Internal Pressure Generated by Electric Discharge Under Water
18610266d Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 4, Apr 88 (manuscript received 19 Mar 86) pp 82-86

[Article by Yu. V. Saprykin, V. N. Tsurkin, I. S. Shvets, and V. K. Sholom, Design Engineering Office of Electrohydraulics, UkSSR Academy of Sciences, Nikolayev]

[Abstract] A thin spherical shell consisting of two identical forged hemispheres which have been welded together along their common periphery is considered for a theoretical and experimental study of the kinetics of hydroelastic deformation by a pulse of internal pressure originating at the center, site of an electric discharge, such a shell being filled with and surrounded by water. The experiment was performed with a spherical shell of 1Cr18Ni10Ti steel, its radius being 0.22 m and its wall being 2 mm thick. A current pulse was transmitted from the gap of a controllable spherical discharger by a coaxial electrode piercing the wall to the center of the shell. The experimental data, namely pressure transducer and strain gauge readings as well as oscillograms, have been evaluated statistically relative to measurement errors for verification of a theoretical analysis based first on a point source of pressure pulse and then on a finite source with perfectly soft boundary. The agreement has been found to be satisfactory. Figures 5; tables 1; references 8: 6 Russian, 2 Western (both in Russian translation).

UDC 533.6.013.42

Axisymmetric Problem of Thin Elastic Spherical Shell Dropping Into Compressible Fluid
18610266c Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 4, Apr 88 (manuscript received 17 Dec 86) pp 63-74

[Article by V. D. Kubenko, Institute of Mechanics, UkSSR Academy of Sciences, Kiev, and V. V. Gavrilenko, Kiev Institute of Automobile Roads]

[Abstract] The axisymmetric problem of thin elastic spherical shell dropping into a slightly compressible ideal weightless barotropic fluid after having fallen vertically on the free surface of the latter is formulated in the linear approximation for four different boundary conditions at that surface, assuming that the shell surface is impermeable to the fluid and that perturbations produced in the fluid by the shell die out at infinity. 1. The fluid surface moves horizontally but does not rise around the striking shell. 2. The fluid surface moves horizontally and rises around the striking shell. 3. The fluid surface is constrained by a "rigid" shield. 4. The fluid surface is constrained by a "deformable" shield. The first two are mixed boundary-value problems, of the hyperbolic kind, of mathematical physics. The first two are Neumann boundary-value problems. All four are solved according to the same procedure, which begins with solution of two auxiliary problems. The first one is establishing the relation between rate of deformation of the fluid surface and hydrodynamic pressure on that surface, both as functions of time and of the angular space coordinate being expanded into infinite Fourier series in Legendre polynomials and the corresponding wave equation being Laplace transformed. The second problem is establishing the relation between normal displacement and velocity as well as tangential displacement of points on the median shell surface and pressure of the fluid, all again being functions of time and of the angular space coordinate. For the first three boundary conditions the main problem of shell and fluid interaction thus reduces to an infinite system of linear Volterra integral equations of

the second kind with respect to the coefficients in the Fourier series of hydrodynamic pressure, for the fourth boundary condition it reduces to an infinite sequence of such equations with respect to the same coefficients. For more expeditious numerical solution and analysis, with variation of parameters in dimensionless form, the convergence of the Fourier series is improved by means of Gibbs multipliers. Numerical calculations by this method have been made for a spherical steel shell. Figures 5; references 6: Russian.

UDC 539.3

Parametric Vibrations of Shells of Revolution With Variable Parameters
18610266b Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 4, Apr 88 (manuscript received 28 Feb 86) pp 52-57

[Article by A. T. Vasilenko and P. N. Cherinko, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Parametric vibrations of thin shells of revolution closed around the circumference but otherwise of arbitrary shape, consisting of several orthotropic and isotropic layers of variable thickness, are analyzed in accordance with the linear theory of shells with the hypothesis of nondeformable normals for the entire stack as a whole. The material of each layer is assumed to be elastic and to obey Hooke's law generalized, deformation of such a shell prior to loss of stability being describable by a system of partial differential equations according to the zero-moment theory. The problem of parametric vibrations is solved analytical and then numerically for two shells: first an orthotropic truncated conical one, then a compound one consisting of a cylindrical segment and a conical segment with a matching transition segment of a parabolic shell between them. Figures 4; tables 2; references 9: 8 Russian, 1 Western (in Russian translation).

UDC 539.3

Refinement of Shear Theory for Shallow Orthotropic Multilayer Shells
18610266a Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 4, Apr 88 (manuscript received 16 Jul 86) pp 32-37

[Article by A. O. Rasskazov and A. V. Burygina, Kiev Institute of Automobile Roads]

[Abstract] The shear theory for orthotropic multilayer shells developed by A. O. Rasskazov in 1976 (PRIKLADNAYA MEKHANIKA Vol 12, No 11) is refined by constructing the second-order approximation so as to account, invariantly with respect to the number of layers, for the curvature of a normal to the surface during deformation as well as for the nonuniformity of shearing strain distribution upon crack formation along interlayer boundaries with attendant parting and resulting violation of smoothness. The refined version, based on the same hypothetical distribution of transverse shearing stresses, extends Hooke's law and Cauchy relations for all components of both stress and strain tensors with the aid of equilibrium equations in the three-dimensional theory of shells. It is applied to shallow shells. For the specific case of a triple-layer shell, and distributions of transverse shearing and tangential normal stresses in the second approximation are compared with those in both zeroth and first approximations. Figures 2; references 12: Russian.

UDC 533.6.013.42

Numerical Study of Axisymmetric Waves in Elastic Cylindrical Shell Filled With Viscous Compressible Fluid
18610245b Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 2, Feb 88 (manuscript received 17 Feb 86) pp 50-54

[Article by I. M. Nochkin, I. A. Pashkov, and I. Ye. Troyanovskiy, Moscow Institute of Electronic Machine Design]

[Abstract] Free longitudinal-transverse waves in an elastic cylindrical shell satisfying the Kirchhoff-Love hypotheses and filled with a viscous compressible fluid are studied on the basis of the linearized Landau-Lifshitz equations for small oscillations of a barotropic fluid and the Kirchhoff-Love matrix equation of motion for a shell transmitting harmonic waves. Numerical integration of these equations by the Godunov method of multiple orthogonal passes (with complex arithmetic and application of the Mueller method for root extraction) has yielded both frequency and attenuation characteristics of such waves, also the frequency dispersion, depending on the shell properties (wall thickness, Poisson ratio) and on the fluid properties (density, viscosity). Figures 5; references 12: 10 Russian, 2 Western.

UDC 539.3

Action of Acoustic Waves on Spherical Shell Filled With Viscous Compressible Fluid
18610245a Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 2, Feb 88 (manuscript received 23 Jan 86) pp 43-49

[Article by I. G. Guseynov, Institute of Mathematics and Mechanics, AzSSR Academy of Sciences, Baku]

[Abstract] The action of a plane acoustic rarefaction wave on a spherical shell filled with a viscous compressible fluid is analyzed, a state of stress and strain being produced in such a shell by the resultant field of both incident and reflected rarefaction waves. The total hydrodynamic pressure on the shell is expressed in terms of the wave potential, namely its series expansion in spherical Bessel functions (incident wave) or Hankel

functions (reflected wave) with Legendre polynomials as coefficients. Axisymmetric deformation of the shell is described by a system of two partial differential equations according to the engineering theory of moments. Motion of the fluid, quiescent with only small oscillations, is described by the linearized Navier-Stokes vector equation. After the general solution has been obtained, it is applied to the two special cases of vacuum and an ideal fluid inside the shell. Numerical stress calculations have been made for two practical cases. In the first case a shell containing naphtha, kerosene, or air was immersed in water. In the second case a shell containing naphtha, kerosene, or water was immersed in air. For both cases low-frequency (32, 40, 48 Hz) and high-frequency (480, 635, 800 Hz) rarefaction waves in the acoustic medium around the shell were considered. Figures 2; tables 1; references 8: Russian.

UDC 533.6.011

Asymptotic Solution to Problem of Hypersonic Flow Past Blunt Axisymmetric Bodies Within Zone of Shock-Layer Separation Under Zero Limiting Pressure

18610289a Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA, SEIYA 1: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 8, Apr 88 (manuscript received 17 Feb 85) pp 68-71

[Article by A. A. Sytikov and V. N. Engelgart]

[Abstract] Steady hypersonic flow of a perfect gas past a smooth blunt axisymmetric body is considered, assuming an infinitely high Mach number prior to the perturbation and a unity adiabatic exponent k making the shock layer degenerate into a one-dimensional one. The corresponding system of four Euler equations for its separation zone, where the limiting pressure approaches zero and the Lighthill solution becomes irregular, is solved by asymptotic integral iterations of the pressure coefficient $P_1(b,e)$. Here b is the coordinate along the shock-wave contour with the origin on the body's axis of symmetry and e is (k minus 1)/(k plus 1), the pressure p on the body surface being approximately equal to $e^{3/2}p_1(b,e)$. References 5: 3 Russian, 2 Western (1 in Russian translation).

UDC 533.6.011.55

Viscous Supersonic Flow Past Sphere With Concurrent Subsonic or Sonic Injection

18610244b Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 1, Jan 88 (manuscript received 16 Sep 85) pp 83-89

[Article by A. M. Grishin, O. I. Pogorelov, and S. I. Pyrkh, Tomsk]

[Abstract] Viscous supersonic flow past a sphere with concurrent subsonic or sonic injection at a given constant rate is analyzed numerically on the basis of the complete applicable system of Navier-Stokes equations for steady axisymmetric flow and the Rankine-Hugoniot relations for the shock wave. Calculations have been made for one quadrant of the sphere, with the Mach number of the quiescent stream varied from 6 to 10 and the Reynolds number in the shock layer varied from 10^2 to 10^4. The relative injection rate and the Mach number of injection flow were varied from 0 to 1.5 and from 0.05 to 1 respectively. The aerodynamic parameters, namely the coefficients of friction drag and pressure drag characterizing both components of resistance, have been calculated taking into account stagnation as well as injection. Figures 5; tables 1; references 11: Russian.

UDC 533.6.011.55

Characteristic of Heat Transfer at Surface of Triangular Body in Hypersonic Stream of Viscous Gas

18610244a Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 1, Jan-Feb 88 (manuscript received 3 Jul 86) pp 77-82

[Article by G. N. Dudin, Moscow]

[Abstract] Interaction and heat transfer between a thin triangular body with a power-law profile and a hypersonic stream of a viscous gas is analyzed, assuming a zero angle of attack and thus a symmetric flow past the body and a characteristic thickness of the latter comparable with the displacement thickness of the boundary layer. The surface temperature of such a wing is given and a linear temperature dependence of the gas viscosity is considered. The corresponding system of partial differential equations for the three-dimensional boundary layer is formulated in two independent Dorodnitsyn variables and solved, with the aid of the "shearing wedge" formula, for the parameters of that layer with frictional stresses and for the thermal flux at the surface. Figures 5; references 5: 3 Russian, 2 Western (1 in Russian translation).

UDC 539.3

Stability of Ribbed Spherical Shell With Initial Camber

18610118c Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 7, Jul 88 (manuscript received 6 Mar 87) pp 58-63

[Article by I. Ya. Amiro, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] Stability under compression of a spherical shell with a square grid of equally stiff reinforcing ribs and an initial imperfection in the form of a camber is analyzed not according to the linear theory of stability, which yields much higher critical loads than experimental data indicate, but according to the theory of structurally orthotropic shells with the inertia term omitted in

the two linearized fourth-order partial differential equations which describe flexure with buckling of such a shell. The initial camber is assumed not to infringe on the convexity of the shell, this condition determining its maximum allowable amplitude, and to run across the entire region where the primary depression will form upon loss of stability in buckling. The shell is assumed to be shallow within that region. The stability limit of panels inside the square frames formed by the two orthogonal arrays of ribs is found by calculating the critical force for a smooth shell. Then, assuming that sheath and ribs are made of the same material, the efficiency of the reinforcement is evaluated in terms of optimality relative to a smooth shell having the same mass. The influence of initial camber on the magnitude of the critical compression load and dependence of the latter on the structural parameters of the reinforcement are subsequently evaluated for the case of ribs with rectangular cross-section. Figures 4; references 3: Russian.

UDC 533.6.011

Gasdynamics Characterizing Interaction of Supersonic Jet and Dead-End Channel
18610289b Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 8, Apr 88 (manuscript received 12 Feb 85) pp 72-75

[Article by Ye. A. Ugryumov]

[Abstract] Buildup of flow oscillations in a dead-end channel during its interaction with a supersonic jet is considered and a mathematical model of the limit cycle is constructed by combining results of numerical analysis with results of physical experiments. On the basis of this model are then calculated the gasdynamic parameters of subsequently steady oscillations during continued inrush of an underexpanded supersonic jet, their longitudinal profiles and their dependence on the Mach number of the entering jet. Figures 2; references 6: 5 Russian, 1 Western (in Russian translation).

UDC 531.391

Calculation Modes for Mechanical Analysis of Automatic Manipulators in Industrial Robots
18610266e Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 4, Apr 88 (manuscript received 17 Dec 85) pp 115-121

[Article by O. B. Korytko and V. I. Yudin, Leningrad Polytechnic Institute]

[Abstract] A method of calculating the dynamic loads on an automatic manipulator in an industrial robot including their extreme magnitudes is outlined, its elementary physical model being motion of two adjacent bodies relative to one another and its gist being application of the theorem about change of angular momentum. Calculation modes are established for two cases, namely translatory or rotary motion of body k with given velocity and acceleration relative to body k-1 moving in a known compound mode. Both cases are combined by treating the point of contact as a pole and the center of inertia of body k as a point moving in a compound mode, the acceleration of both points being then describable by the same general expression. On this basis can be determined running and starting torques of the manipulator drives. The calculations by this method have been programmed in FORTRAN-4 language. They have been performed on a computer for an industrial robot consisting of two MEPV-3-90-1.3-1200 translatory modules and two MEPV-3-90-1.3-310 rotary modules with 90 W drive motors each. Figures 5; references 21: 11 Russian, 10 Western (1 in Russian translation).

UDC 621.01:621-52

Reduction of Friction Forces in Industrial Robot to Generalized Coordinates and Synthesis of Compensating Regulator
18610111a Moscow MASHINOVEDENIYE in Russian No 5, Sep-Oct 88 (manuscript received 8 Oct 87) pp 56-62

[Article by L. M. Bolotin and L. I. Tyves, Moscow]

[Abstract] A method of calculating friction forces and moments in automatic manipulators of industrial robots with zero-clearance transmission mechanisms is proposed, this method involving reduction of friction forces and moments to generalized coordinates with the aid of matrix calculus for the purpose of their compensation by means of a nonlinear regulator. The problem is formulated and solved for the quasi-static case, assuming constant load forces and constant velocities. The generally difficult problem is simplified by first considering a differential drive mechanism with only two degrees of freedom, one translation and one rotation, before the algorithm of friction compensation is constructed for n degrees of freedom on the basis of the corresponding equations of statics. The composite structural and functional scheme of a regulator compensating all friction forces and moments with spring action is developed in accordance with that algorithm. The effectiveness of the method is demonstrated on friction calculation for a manipulator arm of the TUR-10K industrial robot. Figures 2; tables 1; references 5: 4 Russian, 1 Western (in Russian translation).

UDC 531.8

Design of Manipulator Movements for Given Object Position
18610238c Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 88 (manuscript received 30 Jul 84) pp 104-110

[Article by E. V. Kloyko, Kalinin]

[Abstract] Movements of a universal anthropomorphous manipulator with three translational and three rotational

degrees of freedom are analyzed in both a stationary system of coordinates fixed on the base and a movable one fixed on the grip. The matrix equation is explicated for a rectangular manipulator, whereupon cylindrical and spherical manipulators are also considered. The inverse problem of designing the manipulator movements for a given object position is solved first analytically and then, for illustration, numerically in connection with a manipulator of a typical vertical milling machine tool. Both analytical method and numerical procedure are applicable, upon inclusion of appropriate geometrical constraints, to many industrial robots such as the RF-202M, the PR-1OI, and the SM40Ts401 4 DOF robot with cylindrical transfer schemes. Figures 4; tables 1; references 10: 8 Russian, 2 Western (1 in Russian translation).

UDC 523.24:521.1

Topocentric Angular Velocity of Orbiting Artificial Earth Satellite

18610289c Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 8, Apr 88 (manuscript received 8 Jun 87) pp 119-121

[Article by S. P. Rudenko]

[Abstract] An expression is derived for the topocentric angular velocity of an orbiting artificial earth satellite, in the approximation of a nonrotating earth. The derivation is based on the energy integral applicable to celestial mechanics and astrophysics. From this expression are obtained the maximum angular velocity of a satellite covering the entire surface of the earth in elliptical orbits and the maximum angular velocity of one circularly orbiting the earth along a given latitude. On this basis the necessary angular velocities of a tracking telescope can be determined. Tables 2.

UDC 62-501-12

Turning of Solid Body Optimally With Respect to Impulse of Control Torque

18610267c Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 5, May 88 (manuscript received 18 Apr 86) pp 99-104

[Article by V. I. Gulyayev, V. L. Koshkin, and Yu. A. Shinkar, Kiev Institute of Construction Engineering]

[Abstract] Turning a solid body through a certain angle in space within a certain time by a control torque is treated as an optimization problem and formulated in two right-hand orthogonal systems of coordinates with a common origin at the center of mass: an inertial system and one rigidly coupled to the body so that its axes coincide with the principal central axes of inertia of the latter. Solution of this problem, a nonlinear one without simplifying assumptions but with the magnitude of the control torque constrained by an upper limit on each of its three orthogonal vector components in space, reduces to solution of the Cauchy problem for the system of control equations. This yields an isoperimetric problem for calculus of variations, which is solved with the aid of Lagrange multipliers. Numerical calculations have been programmed in FORTRAN and ASSEMBLER languages for a YeS-1045 computer, equations of motion and variational equations being integrated by the Runge-Kutta method with fourth-order precision and definite integrals being evaluated according to Simpson's rule. Figures 2; references 7: 6 Russian, 1 Western (in Russian translation).

UDC 531.8

Algorithm of Motion Stabilization Ensuring Optimum Distribution of Support Reactions for Walking Machine

18610238b Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 88 (manuscript received 17 Dec 86) pp 82-88

[Article by Yu. V. Bolotin, Moscow]

[Abstract] Motion of a multipedal walking machine is analyzed, for the purpose of its control by feedback which will ensure stability of the programmed trajectory and optimum distribution of the support reactions. The walking machine is described as a massive body with massless legs on point feet. The motion of legs during transfer of the weight is assumed not to influence the system dynamics and the program of movements is assumed not to include explicit feedback from support reactions. The feet are assumed to slip and to impose kinematic constraints on the variables of motion. Two equations of motion for the center of mass, its translation and rotation, are formulated in an absolute reference system fixed to a place. They are subsequently linearized and projected onto the axes of a system of coordinates moving with the body. A law of support control is obtained which, while physically equivalent to an artificial viscoelastic compliance of legs, reduces these equations to a system singularly perturbed in the scale factor. Two theorems are stated pertaining to stability of a statically controllable programmed motion, with both potential energy of the positional control component and dissipation function of the viscous control component being strictly convex. An optimality criterion for contact without slippage is then selected on the basis of a third theorem, this one pertaining to stability in the presence of friction. The dependence of controlling reactions on the feedback amplification factor is found to be a multiplicative one. Figures 2; references 10: 8 Russian, 2 Western (1 in Russian translation).

UDC 531.8

Analysis of Equations Describing Dynamics of Elastic Manipulator With Electromechanical Drives

18610238a Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 88 (manuscript received 29 Jul 86) pp 75-81

[Article by L. D. Akulenko and S. A. Mikhaylov, Moscow]

[Abstract] Motion of an electromechanically-driven elastic two-link manipulator describable by an anthropomorphous model is analyzed on the basis of seven conventional and two additional assumptions. The conventional assumptions are: 1) the lengths of the two links not necessarily equal but of the same order of magnitude, 2) the first link mounted on a bas through two cylindrical hinges at the "shoulder", the vertical pivot axis of one stationary and the horizontal pivot axis of the other rotating, and a third cylindrical hinge mounted at the "elbow" with an also horizontal pivot axis under the condition of a not elastically deformed second link, 3) the load, reducible to a point mass, located at the free end of the second link, 4) both links, straight beams subject to flexure and torsion, made of homogeneous and elastic material, 5) elastic displacements of load and manipulator smaller than the lengths of both links, 6) the manipulator mass smaller than the load mass, 7) three moments of forces produced in the three hinges as well as a force applied to the load and the reaction of the base acting on the manipulator with the load. The additional assumptions are: 1) the kinetic energy of each electric drive with speed reducer determined principally by the high speed of the rotating motor armature characterized by a given moment of inertia, 2) the potential energy of the electric drives reducible to the potential elastic-deformation energy of the speed reducer elements characterized by a given spring rate each. The equations of motion are derived by the standard method of the Lagrange principle. They are analyzed for the extreme case of a perfectly rigid speed reducer and perfectly rigid links, the system being singularly perturbed when the spring rates become asymptotically large. The equations are also used for analytical solution of the problem of moving a load from an initial position of rest to a final position of rest. The authors thank F. L. Chernousko for helpful discussion of the results. Figures 1; references 12: 11 Russian, 1 Western.

UDC 531.355

Rotation of Solid Body in Magnetic Field

18610115b Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA in Russian No 5, Sep-Oct 88 (manuscript received 2 Oct 87) pp 87-91

[Article by N. M. Marsheva]

[Abstract] Steady rotation of a ferromagnetic or superconducting solid body in a magnetic field with attendant Barnett and London effects is analyzed for stability, considering the cases of integrable equations. The angles are sought at which the potential energy, a function of the rotation angle, has isolated minima. With the kinetic energy expressed in Euler variables, integration is performed by the same method as integration of the Lagrange equations but with function f(x) of a generalized coordinate being a fourth-degree rather than third-degree polynomial and therefore having four instead of three roots. Geometrical description of the motion on a Poisson sphere yields an apex moving along a wavy spherical curve which remains confined between two parallels but so that the two poles are equivalent, rather than along a trajectory with loops and cusps biased toward the upper pole as in the Lagrange case. An apex trajectory can, accordingly, asymptotically approach either one of the two poles in the case of unstable permanent rotation and a parallel in the case of unstable precession. Figures 2; references 6: Russian.

UDC 531.383

Effect of Horizontal Accelerations on Accuracy of Gyropendulous Stabilizer

18610115a Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA in Russian No 5, Sep-Oct 88 (manuscript received 17 Jul 87) pp 84-87

[Article by I. V. Shmanenkova]

[Abstract] Stabilization of a gravimeter by means of a gyropendulum is considered, the principal error of such a stabilizer and thus of the gravimeter readings being caused by perturbing horizontal accelerations. Assuming first that these perturbations are monoharmonic and accordingly ignoring all frequencies except the fundamental, it has been shown to be possible to compensate for this systematic error with the error caused by tilting of the platform and by strong damping of the gyrohousing oscillations about the axis of precession. Now the feasibility of its compensation with the error due to tilting of the platform is demonstrated on a less restrictive premise, namely by taking into account the random nature of perturbing horizontal accelerations and considering their entire frequency spectrum. A vessel moving along a straight course at a constant speed is assumed to carry a gyropendulous stabilizer with a single gyromotor, the latter in a mounting which orients the vector of angular momentum vertically and the precession axis horizontally. An angle transducer transmits rotation of the gyromotor to a correcting device which generates a moment applied through another transducer to the precession axis, while the gyroscopic moment strives to turn the gimbals into their original position with the gyroscope axis oriented vertically. The correcting device is characterized by two design and performance parameters, namely stiffness and coefficient of viscous friction. Analysis and solution of the two linearized differential equations of motion for this system, in the first approximation, yield the combinations of values of both parameters which will limit the systematic gravimeter error to

any given permissible magnitude including its reduction to zero. The author thanks V. L. Panteleyev for formulation of the problem and undiminishing attentiveness. Figures 2; references 3: Russian.

UDC 532.51

Kinematic and Energy Characteristics of Wave Propagation Through Visoelastic Multilayer Hollow Cylinder

18610118b Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 24 No 7, Jul 88 (manuscript received 5 May 86) pp 43-48

[Article by G. A. Voropayev and V. I. Popkov, Institute of Hydromechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] The problem of wave propagation is solved for an infinitely long hollow cylinder made of a radially nonhomogeneous viscoelastic material so that it becomes, in effect, a multilayer one and can serve as model of a thin multilayer coating. The system of 9Q equations describing forced vibrations of such a cylindrical coating comprises 3Q linearized equations of momentum conservation and 6Q equations of generalized Hooke's law, with interlayer boundary conditions of stress compatibility and with the innermost layer either rigidly bonded to the substrate or its surface remaining free while an axisymmetric wave load moving axially on the surface of the outermost layer produces traveling-wave perturbations. The equations of motion reduce in this case to a system of Besel equations. An analytical solution of this problem taking into account energy dissipation is followed by a numerical solution with variation of static and dynamic shear moduli as well as of relaxation time. Figures 4; tables 1; references 10: Russian.

UDC 620.178.15

Experience With, Problems In, and Outlook for Use of Computerized X-Ray Tomography in Machine Manufacturing

18610111b Moscow MASHINOVEDENIYE in Russian No 5, Sep-Oct 88 (manuscript received 3 May 88) pp 89-93

[Article by V. V. Klyuyev, E. I. Vaynberg, M. L. Fayngoz and S. G. Tsyganov, Moscow]

[Abstract] Development of industrial computerized x-ray tomography is being intensely pursued, despite its unprecedented complexity and the tremendous scientific effort it requires, the principal reason being the rapidly expanding range of its possible applications which include nondestructive inspection for quality control in the machine manufacturing process. A major achievement so far is the VT-300 computing x-ray tomograph already produced commercially by the Moscow Scientific-Industrial Association "SPEKTR". Its design combines in a flexible manner the new method of highly sensitive tomographic inspection, a contactless method, with conventional digital x-radiography offering the advantages of permanent information storage. Its effectiveness has been demonstrated in the manufacture of machinery ranging from gas turbines and electric motors to reflex cameras. Local high-sensitivity tomography involves geometrical analysis of two-dimensional structural weakness distribution with the aid of a scanning x-ray beam and an x-ray detector, a square-law filter, and x-radiogram processing equipment. The method is applicable to machine parts made of metals such as iron, steel, copper, aluminum and even to machine parts made of wood, most difficult being tomography of parts made of composite materials. The three major problems with computerized x-ray tomography are that it requires the most powerful x-ray tubes and beam accelerators, that its space resolution is not yet sufficiently high, and that the tomogram reconstruction algorithms require complete information. Progress in tackling these problems is made and the outlook is excellent. Figures 9; references 5: Russian.

UDC 620.19.05:061.4

Checking Equipment and Instruments

18610076 Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian
No 7, Jul 88 pp 19-21

[Text] The requirements based on the quality of machine-building products are increasing constantly and this means that the number of parameters to be checked and their accuracy are increasing. To estimate these indicators, one must develop the corresponding checking equipment, which should be done simultaneously with an increase of the technical level of the products and should even outstrip it. Therefore, automotive builders are devoting much attention to the given problem. As a result, the instruments manufactured by the sector are becoming ever more accurate and productive. The exhibits of an exhibition devoted to the 70th Anniversary of the Great October Socialist Revolution specifically indicate this. Among them are especially many instruments and units for checking of bearings. The NPO [scientific production association] VNIPP [All-Union Scientific Research and Production Design Institute of the Bearing Industry] and the PO [production association] GPZ-4 play an important role in their development. Checking devices based on electronic modules are also being developed. Let us consider in detail some of these instruments.

The AP-102-1M automatic machine is designed to check the radial clearance of radial ball bearings under shop conditions of the enterprises of the bearing industry. Compared to analogues, it increases the precision of measurements 1.5-fold, increases productivity 1.6-fold, and permits a check of the radial clearance of a bearing according to the scheme with rotating measuring load.

Specifications of AP-102-1M Automatic Machine

Dimensions of bearings to be checked, mm:	
outer diameter	28-72
hole diameter	12-38
width	7-10
Measurement error, μm	1.5
/Checking performance, units/hr	1,000
Number of sorting groups	3
Load during measurement, N	50 plus or minus 5
Overall dimensions, mm	1,000 x 790 x 1,228
Weight, kg	200

The annual saving from introduction of one automatic machine is more than 2,000 rubles

The UKP-1M unit is used to measure the mutual axial displacement (determined by comparison to a model) of the ends of the outer and inner races of radial-thrust ball bearings under axial two-sided load in one adjusting position, and also to determine the stiffness of the bearing and to estimate the quality of their make-up according to different schemes (T, O, Kh).

The instrument consists of a measuring module with two heads, pneumatic module and control console.

The bearing to be checked is installed on a rotary rocking table (for correct orientation of the bearings in the rolling races). The stiffness of the bearing and the quality of its make-up are determined under three different axial loads, created by pneumatic cylinders. Each bearing has its own set of removable accessories, consisting of four parts.

Specifications of UKP-1M Unit

Dimensions of bearing to be measured, mm:	
minimum hole diameter	12
maximum outer diameter	110
width	10-40
Measurement error, μm	1.5
Axial force, N	30-1,000
Voltage (alternating current), V	220
Air pressure, MPa (kgf/cm^2)	0.4-0.6 (4-6)
Overall dimensions, mm	395 x 540 x 1,235
Weight, kg	120

The GE-201 instrument for checking the parts of bevel and cylindrical roller bearings for angles and deviations from linearity is based on a precision table on an air cushion, sign node and inductive and measurement system, which permits one to increase the measurement accuracy and to expand the dimensions of the products to be measured.

Specifications of GE-201 Instrument

Dimensions of parts to be measured, mm	Up to 250
Scale division of reading unit, μm	0.1
Measurement error, μm	0.5
Voltage, V	380
Compressed air pressure, MPa (kgf/cm^2)	0.6 (6)
Overall dimensions, mm	620 x 360 x 210
Weight, kg	100

The annual saving from introduction of the instrument was 5,000 rubles at GPZ-15 in 1987.

The VNIPP-542 machine is used to test general-purpose roller bearings for longevity during radial, axial and combination loads. Boosters are used in the loading system. The rotational frequency of the bearings varies discretely.

The machine permits an increase of the objectivity of estimating the efficiency and equality of the manufactured product and provides comparative tests of bearings, manufactured by CEMA members according to the unified OSPP [Organization for Cooperation of the Bearing Industry] method. It can be built into an automatic line.

Specifications of VNIPP-542 Machine

Dimensions of bearings to be tested, mm:	
hole diameter	15-30
outer diameter	35-70
Rotational frequency of bearings, min^{-1}	3,000-16,000
Maximum load per bearing, N (kgf):	
radial	14,000 (1,470)
axial	5,880 (588)
Power of drive, kW	2.3/2.9
Overall dimensions, mm	970 x 950 x 1,360
Weight, kg	700

The KVP-3 unit is used to check bearings manufactured according to GOST [State Standard] 529-71 or by special specifications, in laboratories, in the shops of bearing plants and upon input check at bearing user enterprises.

It provides a low level of vibration noise and high precision, due to which it can be used when checking especially low-noise bearings.

The unit is supplied with an axial load assembly with self-fixing inertialless pneumatic chamber for transmission of an axial load to the bearing to be checked and has a weight less by a factor of 3, compared to similar units.

Specifications of KVP-3 Unit

Inner diameter of bearing to be checked, mm	8-60
Voltage (alternating current), V	380
Productivity, unit/hr	250-350
Overall dimensions, mm	700 x 1,000 x 1,200
Weight, kg	200

The annual savings is 100,000 rubles.

The Impuls device is used to study the efficiency and to diagnose the condition of roller bearings with liquid and plastic dielectric lubricant. The operating principle of the instrument is based on conversion of mechanical forces upon contact with microirregularities of the working surface of bearing parts to electric signals. The parameters to be measured are: number of contacts and total contact time within a selected time interval, length of single contact, and rotational frequency.

Specifications of Impuls Device

Inner diameter of bearing to be checked, mm	More than 1
Voltage on bearing, mV	5-1,000
Number of contacts to be recorded within 1 second	1×10^6
Total contact time during 1 s, μs	$(0.5\text{-}1) \times 10^6$
Minimum length of contact to be recorded, μs	0.5
Total measurement error, percent	3
Voltage, V	220
Overall dimensions, mm	350 x 300 x 110
Weight, kg	5

The expected annual saving from introduction of the device is 230,000 rubles.

The developer and manufacturer of the considered devices and units is the NPO VNIPP.

The ISP-1 device was developed on Soviet componentry and permits diagnosis of the quality of bearings within a product under laboratory, shop, field and other conditions.

Specifications of ISP-1 Device

Inner diameter of bearings to be checked, mm	5-1,000
Rotational frequency of inner race, min^{-1}	10-50,000
Voltage (direct current), V	12
Overall dimensions, mm	50 x 150 x 30
Weight, kg	200

The annual savings from introduction of one device is 50,000 rubles.

The developers are the MNPO Spektr and the NPO VNIIPP.

The SM-214 automatic machine is used for automatic checking of the radial clearance of instrument ball bearings. The operating principle is sorting three measurements by average value (by two-fold rotation along five groups, of which three groups are "suitable" and two groups are "reject": "small" clearance and "large" clearance).

The automatic machines increase the productivity of checking instrument bearings more than twofold.

Specifications of SM-214 Automatic Machine

Outer diameter of bearings to be measured, mm	4-13
Working load, N	3.5-10
Minimum sorting range, mm	0.004
Measuring head	Induction converter
Productivity, units/hr	1,000
Overall dimensions, mm	515 x 650 x 700
Weight, kg	170

The annual saving is 5,000 rubles.

The developer and manufacturer is PO GPZ-4 (Kuybyshev).

The SM-473 automatic machine (also developed at PO GPZ-4) is designed for multiposition sorting of inner races of instrument bearings along the diameter of the rolling race prior to assembly. It provides precise size sorting of the races due to an installed electronic module and cam command apparatus, is simple and convenient to adjust and operate, and is easily built into an automatic line.

Specifications of SM-473 Automatic Machine

Diameters of holes of races to be graded, mm	1-10
Number of grading groups of races	39
Grading interval, mm	0.002
Misalignment after 4 hrs of operation, mm	0.001
Measuring head	Inductive converter
Voltage, V	380
Power, kW	0.35
Productivity, unit/hr	1,000
Overall dimensions, mm	1,500 x 900 x 1,800
Weight, kg	350

The annual saving from introduction of the automatic machine is 5,000 rubles.

The module for checking the seal of products is used under conditions of individual, serial and mass production. It tolerates test pressure in the product to be checked if a visual search for defects is necessary.

It can operate independently and in semi-automatic machines and automatic lines at enterprises of various sectors of industry.

The control system is electronic and the adjustment method is according to the permissible leakage of the test substance (compressed air).

Specifications of Module

Air pressure during testing, MPa (kgf/cm^2)	0.02-0.25 (0.2-2.5)
Error of pressure maintenance, MPa	plus or minus 0.003
Volume of cavity to be tested, cm^3, not more than	3,000
Operating range of leakage rejection, ncm^3/min	0.5-100
Power supply voltage, V	220
Consumed power, kW	0.14
Weight, kg	78

The module has been introduced at ZIL [Moscow Automotive Plant imeni I. A. Likhachev] to refine the test conditions for the integrity of diesel parts.

The developer is GKTIavtoprom and the manufacturer is the experimental plant of GKTIavtoprom.

The Mikron-003 microchannel instrument is designed for postoperative checking of deviations of the linear dimensions of parts. Unlike foreign analogues, it can be used in manual checking devices or in automatic checking machines and also for active checking within machining equipment.

The instrument consists of one or two electronic modules operating jointly with control elements and display, inductive or differential transformer sensors located in the appropriate measuring equipment or on the equipment. The instrument can be assembled in different configurations with different number of sensors due to its modular design and can be adapted for solution of a specific task as a function of need without significant modification.

Specifications of Mikron-003 Instrument

Measurement range, μm	plus or minus (25-500)
Measurement error, μm	1
Resolution, μm	0.5
Maximum number of two types of sensors	16 (32)
Maximum number of parameters to be checked	8 (16)
Number of rejection groups	5
Consumed power, W	80
Overall dimensions of electronic module, mm	455 x 350 x 290
Weight, kg	8

The expected saving from introduction of one instrument at the engine plant of KamAZ is 5,000 rubles annually.

The developer and manufacturer is KamAZ.

The Mikron-004MP multichannel measuring system is used to measure, reject and grade parts of automatic finish and postoperation checking machines in machining plants of different sectors of industry.

The system is based on microprocessor technology. It has flexibility, permits reprogramming, combines check and control functions of the test devices of the automatic check machine. Unlike similar models, it can operate in the self-diagnostic mode of the efficiency of electronic modules.

Specifications of Mikron-004MP System

Number of connected sensors	Up to 60
Measurement range, μm	plus or minus 100; plus or minus 1,000
Measurement error, percent	0.5
Control:	
number of inputs and outputs	64
voltage, V	24; 100
Power supply:	
voltage, V	220
frequency, Hz	50
Consumed power, W	150
Overall dimensions, mm	470 x 520 x 350
Weight, kg	23

The annual saving from introduction of the system at KamAZ is 15,000 rubles.

The developer and manufacturer is KamAZ.

UDC 658.52.011.56

System for Controlling Robotized Machine Cell

18610002e Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 88 pp 21-22

[Article by V. I. Levitskiy, engineer]

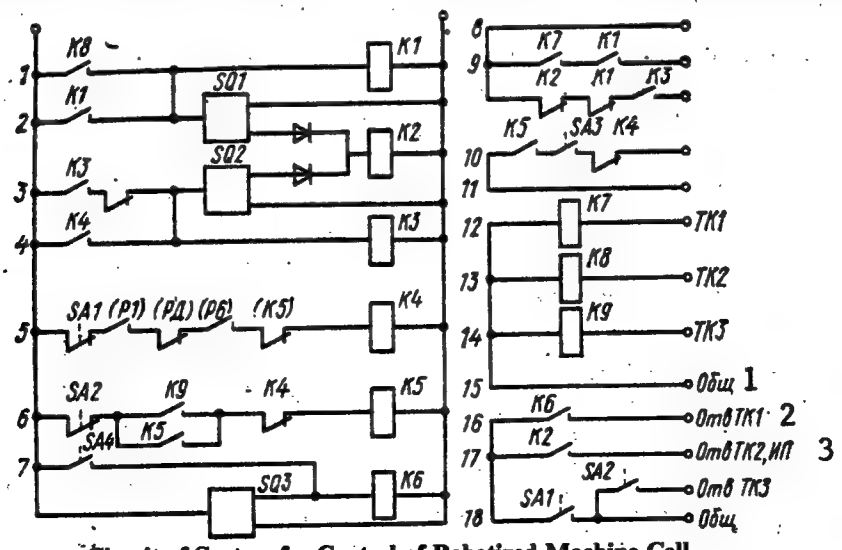
[Text] In developing robot systems, one of the problems that faces developers is that of electrical intercoupling of the control systems of process equipment, auxiliary equipment, and industrial robots. Usually there are a number of conditions and constraints that have to be met, the most general being: minimum possible number of physical constraints; use of the smallest possible number of commands of the industrial robot control system for the needs of peripherals; provision of a set of interlocks; absence of electrical connection between the separate systems that control the equipment making up the robot system.

With consideration of these requirements, a system has been developed, produced and put into operation for electrical interfacing of the R-505 robot with a UTsM-663 programmed control system, and two YeM-473 semiautomatic lathes that are part of a shaft machining robot system.

The machines are equipped with inertial two-jaw self-locking chucks with spring-loaded sinking center. The guard is opened and closed by a screw-and-nut mechanism that is turned by an electric motor. Additionally installed on the machines are three BKV-24 noncontact limit switches for controlling the position of the tailstock, two contact limit switches for controlling the extreme positions of the guard, and a track limit switch for controlling the working cycle of the machine. The system (see diagram) operates as follows.

At the instant of completion of a machining cycle, when the carriage of the machine has returned to the starting position, circuit P1-PA-P6 of the machine control system is prepared, and relay K4 (zone 5) fires, energizing the guard drive motor (not shown on the diagram) through a contactor. The guard begins to move to the right, uncovering the zone of machine unloading and loading. At the same time relay K4 through a contact in zone 4 energizes relay K3 that controls the electromagnet of the hydraulic distributor of motion control of the tailstock sleeve (zone 9), and feeds the noncontact limit switch (NLS) SQ2 that controls the intermediate position of the sleeve during withdrawal. At the instant when the flag connected to the tailstock sleeve enters the zone of operation of NLS SQ2, relay K2 operates that controls the intermediate position of the tailstock sleeve. Through its contacts in zone 9, relay K2 breaks the supply circuit of the electromagnet of the hydraulic distributor for withdrawal of the tailstock sleeve. Withdrawal stops, and the workpiece is between centers. At the instant of complete opening of the guard, NLS SA1 operates, disconnecting relay K4 through its NC contacts in zone 5. Relay K3 remains energized due to the self-latching circuit in zone 3. Relay K2 remains energized as well.

The machine is ready for the loading (unloading) cycle, as indicated by the prepared circuit Sa1-K2 in zones 16 and 18. The inquiry about readiness of the machine for service that comes from the programmed control system of the industrial robot is confirmed by this circuit; the robot arm with first grab open enters the loading (unloading) zone, and the gripper devices close. Process



Circuit of System for Control of Robotized Machine Cell

Key: 1. common 2. response 3. not explained

command TK1, called "sleeve finalizing," comes from the robot control system. Relay K7 operates in the process command reception unit, and restarts the process of withdrawal of the tailstock sleeve through its contacts in zone 8. When the sleeve has reached the extreme rearward position, NLS SQ3 operates, and relay K6 (zone 7) sends a response through its contacts in zone 16 about execution of robot process command TK1. The industrial robot performs a "right-down left" motion cycle. The next blank or intermediate workpiece that is held in the second grab of the robot is on the line between centers, up against the head center.

Process command TK2, called "sleeve feed," comes from the industrial robot control system. Relay K8 (zone 13) fires, its contacts in zone 1 energize relay K1, which is self-latched by its contacts in zone 1, and activate NLS SA1. Relays K2 and K3 are killed as the contacts of K1 open in zone 3. Through its contacts in zone 8, relay K1 energizes the electromagnet of the hydraulic distributor that controls motion of the tailstock sleeve to withdrawal. The sleeve begins to more, and the flag connected to it enters the operating space of NLS SQ1. The latter operates, energizing relay K2 that fixes the intermediate position of the sleeve. Its contacts in zone 9 open, stopping sleeve feed. The contacts of relay K2 in zone 16 generate a response about execution of process command TK2. The industrial robot opens the grab and its arm moves out of the machine zone. Process command TK1 comes again from the industrial robot programmed control system. Relay K7 is energized, and carries out the final feed and locking of the sleeve through its contacts in zone 8 via circuit K7-K1. When the sleeve has reached the extreme left-hand position, NLS SA4 operates in the circuit of relay K6, generating a response about repeat execution of command TK1 through its contacts in zone 16. Upon receiving the response, the programmed control system of the industrial robot outputs process command TK3, called "close guard." Relay K9 fires in zone 14, and through its contacts in zone 6 it energizes relay K5 that closes a contractor to activate the electric drive of the guard, and is self-latched through its own contacts in zone 6.

The guard begins to move to the left. At a certain position of the guard, roughly 200 mm from the left end position, track NLS SA 3 operates in zone 10, and the machine is started. When the guard has reached the extreme left position, NLS SA2 operates, relay K5 is killed, the guard stops moving, and a response is simultaneously sent to the programmed control system of the industrial robot about execution of command TK3 (zone 17). The industrial robot goes to execution of the operations prescribed by the next program step.

The circuit components are mounted on a separate panel fitted with a plug. The panel is placed directly in the electrical box of the machine. To keep things simple, the diagram does not show anti-arcing and manual control circuits. REN-33 relays are used for relays K1-K6, and 24 VAC RPU-0 relays are used for K7-K9, as the process commands from the UTsM-663 control system are transmitted by AC signals with level of 24 or 110 V. DC relays may also be used, but in this event, bridge rectifiers will have to be provided for every relay. Noncontact limit switches SQ1 and SQ2 are connected in a differential circuit for measuring the position of the sleeve to get a fixed stopping point as the flag approaches from either side. Given in parentheses are the numbers of points from the circuit of the YeM 473-4 901.00 EZ3 machine. The system has been in service for two years on four machines.

UDC 621.397.6:Δ629.1.06

Modular Television System for Enhancing Productivity of Robots Under Low-Lighting Conditions

18610002b Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 88 pp 12-15

[Article by V. P. Kucheruk, candidate of technical sciences]

[Text] Industrial television (ITV) installations are currently in extensive use for automating and mechanizing production processes, observing and monitoring operating robots, technological processes, items in storage, and the like. While such systems have given good service, they do have low sensitivity of the order of 50 lx, and cannot be effectively used on a facility during twilight or at night. Putting in added illumination, especially for outdoor work, involves considerable capital expenditures on installing power cables and standards carrying floodlights, and entails enormous expenditures of electrical power. For example, calculations show that replacing the PTU-56 eight-camera ITV installation in a railway freight yard with the proposed TV system using eight cameras, eliminating added lighting and the associated excavation and erection work, saves 60,260 rubles. The saving of electric power in this case amounts to 1,573,000 kWh per year.

The installation of a new ITV series with improved service support that is now in progress does not solve the problem, as some units have no better sensitivity than the old ones. High-sensitivity industrial television systems with the KTP-85 TV camera using a silicon-intensifier target tube are frightfully expensive, which limits their extensive use.

The aforementioned ITV units are produced with CRT transmitting tubes. Industry is now making television cameras designed around a fundamentally new semiconductor component base. The image-transmitting component is a charge-coupled device (CCD): a photosensitive charge-coupled circuit (PCCC) comprising a matrix made up of silicon photocells in which the number of

elements along the vertical is related to the number of lines of the television standard. Let us note that for large-format matrices there are 492-576 lines, and for medium-sized format there are half that many; there are about 700 elements along the horizontal [for the large-format matrix], which is close to the requirements for the television standard, and half that many for the medium format.

Photosensitive charge-couple circuits have advantages over CRT transmitting tubes in the absence of heater circuits with high-voltage supply, quick response and steadiness of the raster, high mechanical strength, low mass and overall dimensions, economic low-voltage power supply, freedom from geometric distortions, and capability of data processing inside the device; however, they have poorer resolution. Among the cameras being produced are the KT-79 with resolution of 150 television lines and working range of illumination of 200-100,000 lx, and the KT-2 using a large-format K 1200 TsM2 PCCC that contains 576x360 elements. The resolution of the camera is 240 television lines, and the working illumination range is 100-20,000 lx. These cameras are designed mainly for use in robotics, and because of their low characteristics they cannot be widely used for other purposes.

The circuitry of the aforementioned cameras is based on a large number of discrete elements, which reduces reliability and increases overall dimensions, mass, power consumption, and cost. At the same time, the KT-2 camera does not take advantage of all capabilities embodied in the K 1200 TsM2 matrix. The theoretical sensitivity of a silicon CCD matrix is 10^{-4} lx; however, the imperfection of technology and circuitry precludes attainment of this value in practice. Design approaches enable the actual sensitivity of a matrix to be brought to 10^{-1} lx.

In parallel with development of various types of CCD imaging photocells, large-scale integrated circuits (LSI chips) have been developed for CCD control and video information processing. LSI chips are industrially produced that replace a large number of discrete components (microcircuits, transistors, diodes, and so on). A miniature television camera with enhanced sensitivity has been developed around this new semiconductor component base.

Technical Specifications of the Camera

Resolution along the horizontal for an object Illuminated at the 5 lx level, lines	Up to 280
Number of reproducible brightness gradations	At least 7
Threshold sensitivity on object in wavelength Range from 0.8 to 0.9 μm, lx	No worse than 0.5
Supply voltage, V	12-15
Power consumption, W	1.7
Overall dimensions without objective lens, mm	60x45x40

The reason for the high sensitivity of the camera in the near infrared region of the spectrum is that the silicon PCCC has maximum sensitivity in this spectral region. Tests of the camera have shown that booster lighting of the object by diffuse light from an incandescent lamp that has maximum output in the near infrared allows observation of the object on a video monitor screen at illuminance of about 0.5 lx. Resolution in this case decreases, as exposing infrared radiation with wavelength of more than 0.85 μm begins to penetrate to a greater depth in the PCCC matrix, covering adjacent regions of the structure with diffuse spreading of charge carriers into adjacent photosensitive cells. A block diagram of the device is shown on Fig. 1.

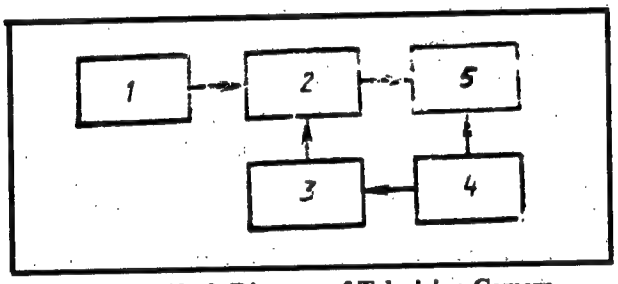


Figure 1. Block Diagram of Television Camera

Key: 1. Objective lens 2. K 1200 TsM PCCC 3. K 1124 PU1 current switches 4. K 1124 AP1 sync generator 5. Video amplifier

The cost of the television camera was kept low by the low cost of the components. Subsequently, as a result of added design features, the technical characteristics, stability and reliability of the camera were improved, enabling production of a model shown in two modifications on Figure 2. The camera of cylindrical shape has a mass of 250 g, and overall dimensions of 48x140 mm, while the rectangular unit masses 300 g and measures 110x55x50 mm. A video amplifier enables transmission of a complete television signal over a coaxial cable to a distance of as much as one kilometer. Signal output in digital form is provided for computer processing of the image. Industrial production of the video camera was started in 1988 at a plant in Novogorod. This camera necessitates a fundamentally new design of the industrial television system, and new operating conditions. The system includes main and reserve cameras, which enhances serviceability. In developing the new television system, the goal was multifunctional application; to this end, use was made of advances of modern engineering in the area of data transmission based on semiconductor coherent emitters and fiber optics.

Figure 3 shows a block diagram of the TV system. The television camera is equipped with an optical attachment (OA), and is accommodated in a light-tight, waterproof and dustproof container mounted on an aiming unit (AU). In the container are mechanisms for wiping dirt from the protective glass, focusing, and irising the objective lens. These are driven by a command from a control console (CC). A semiconductor emitter of intense infrared radiation may be fastened next to the

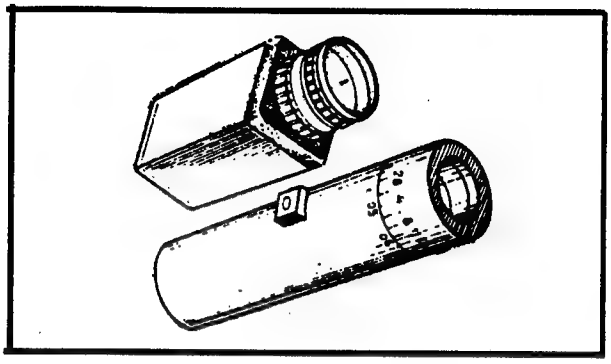


Figure 2. Miniature Television Camera With Improved Characteristics

container. The pulse generator of the emitter is mounted on a platform next to the AU.

Three modifications of the AU have been developed: remote-control, dependent, and manual. The main television camera is carried on a remote-control AU. The remote-control AU consists of two parts: moving and stationary. The moving part carries the container with the TV camera and the booster emitter. The optical attachment of the camera, which is controlled by commands from the CC, includes an objective lens, and irising and focusing units that are driven from two miniature reversible 12 VDC motors with gearboxes. The standard objective lens used in the OA focuses the image on the reception area of the PCCC measuring 7x5 mm. It has a focal length of 20.2 mm and speed of f/1.5. For observation of remote objects under low-light conditions, a long-focus objective lens is used with relative aperture of 1:1 and focal length of 60 mm.

The stationary part of the AU includes: a stabilized power supply, control command decoder, controlling devices, and mechanism for rotation in the vertical and horizontal planes. The mechanisms are driven by two reversible 12 VDC motors. The angle of rotation is limited by microswitches and can be regulated. The operating mode of the AU is selected by the operator at the CC. Angle of rotation in the horizontal plane (180 plus or minus 5)°, angle of rotation in the vertical plane (45 plus or minus 5)°. Speed of aiming along the horizontal 6 plus or minus 1.0 deg/s.

The stabilized DC power supply feeds appropriate voltages to: television camera, decoder, optical transmitting module with coherent emitter, photoreceiver amplifier, video signal commutator, electric motors of the AU and OA, and pulse generator of the booster light emitter. The power supply operates from an AC line on voltage of 220 V plus or minus 10 percent, frequency 50 Hz plus or minus 1 percent, from a DC source on voltage of 12-27 V, and has electronic surge protection.

The decoder processes control commands that may be transmitted over fiber-optics communication lines (FOCL), by optical radiation through the atmosphere, or over a two-wire line from the control console. The

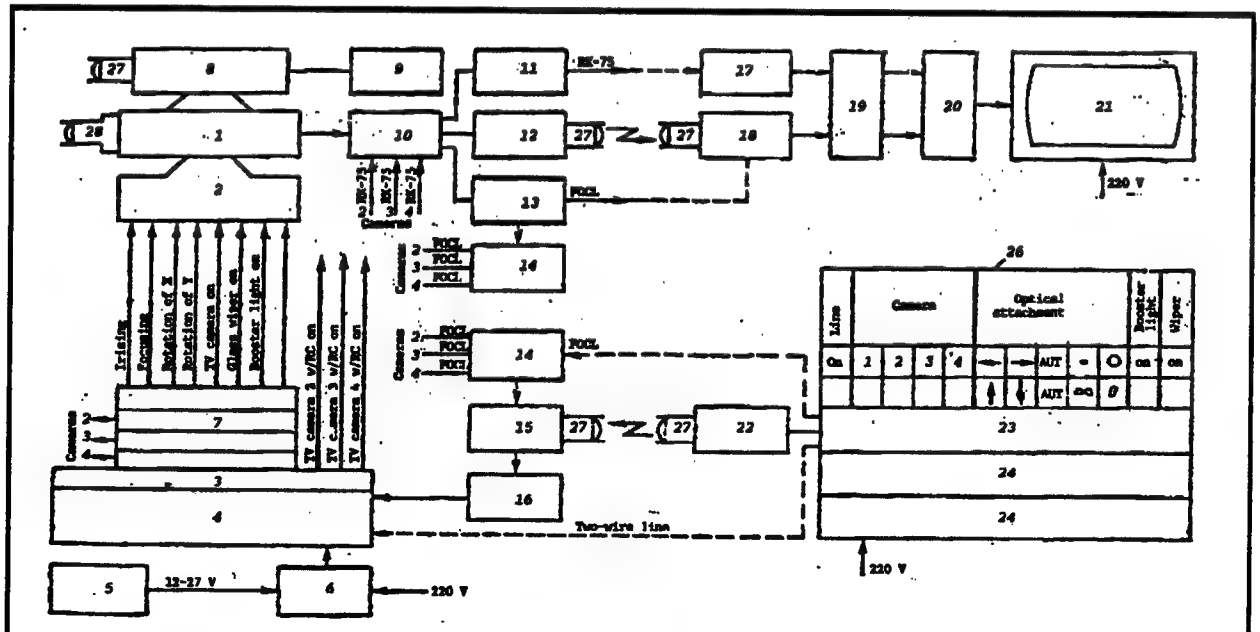


Fig. 3. Block diagram of television system: 1 -- television camera; 2 -- actuating mechanisms; 3 -- controlling devices; 4 -- decoder; 5 -- accumulator; 6 -- stabilized power supply; 7 -- TV camera hookup cables; 8 -- booster light emitter; 9 -- pulse generator; 10 -- video signal commutator; 11 -- video amplifier; 12 -- video signal emitter; 13 -- optical transmitting module; 14 -- optical splitter; 15 -- control command photoreceiver; 16 -- amplifier; 17 -- linear video amplifier; 18 -- video signal photoreceiver; 19 -- distributor amplifier; 20 -- complexer; 21 -- video monitor; 22 -- control command emitter; 23 -- coder amplifier; 24 -- coder; 25 -- stabilized power supply; 26 -- control console with light display; 27 -- objective lenses; 28 -- optical attachment

decoded and amplified command signals operate controlling devices that feed the corresponding voltages from the stabilized power supply to the units of the TV system and the actuating mechanisms of AU and OA.

The dependent aiming unit has only actuating mechanisms that are linked to the rotations of the TV camera, focusing and irising of the objective lens, and wiping of the protective glass. The actuating mechanisms and functional units are turned on by controlling devices of the AU of the main camera. By using the manual aiming device, the camera is brought to the object of observation and is secured in the working position.

In its entirety, the TV system is made up of four television cameras accommodated on different aiming units, two control consoles, and two video monitors, one of the monitors and one of the aiming units being self-contained. If the system incorporates aiming units analogous to the main camera, then when a selected TV camera on an AU is switched on, all control signals pass to the decoder of the AU of this camera. In the case of an independent AU that has no power supply, decoder or controlling devices, the actuating mechanisms are controlled through the modules of the AU of the main television camera, to which the dependent AU is connected by an eight-conductor cable. This also applies to the manual AU, which is connected to the AU of the main camera by a five-conductor cable. When control commands are transmitted over a fiber-optics communication cable, the signal goes to an optical splitter and from there to the photoreceivers of the TV cameras, which are accommodated only on aiming units similar to that of the main camera. The video signal from the television cameras goes through an optical transmitting module to the optical splitter, and from there through the FOCL to the photoreceiver at the reception end. POM-4A, POM-5 and POM-11 transmitting modules are used for video signal transmission in analog form, and the POM-3 is used for transmission in digital form.

The television cameras may be located at a distance of as much as 1 km from the main camera, and the range of transmission of a video signal from the splitter to the photoreceiver is at least two kilometers. If the TV system consists of a single camera, the range of transmission of the video signal and control signals is at least four kilometers. A combined version is possible, where the transmission of video signal and control signals between the sending and receiving sides is by FOCL, while transmission between cameras is over a control cable and coaxial cable. In this case, the video signal goes to a video signal commutator, and from there to the optical transmitting module installed with the main camera.

The presence of two control consoles and two monitors allows a complete TV system to be configured as two independent systems consisting of a control console, video monitor, and two TV cameras, one of which is the main camera. This gives an operator the capability of simultaneously observing two objects, and independently controlling two cameras. Let us note that the cameras are connected in series in a four-camera TV system.

The simplest TV system is comprised of a camera without container installed on a manual AU that has a stabilized 12 VDC power supply and a video monitor. The power supply is located next to the monitor. The camera is connected to the monitor by coaxial cable.

In the vehicle-borne modification (aircraft, ship, train), the TV system transmits the video signal by FOCL with low-power POM-4A module. There may be as many as four TV cameras, with independent operation of two cameras into one monitor through a complexer that is part of the TV system. This version of the system is also convenient for installation on commuter trains so that the driver can use a monitor to watch passengers boarding and leaving on the last cars.

The arrangement with communication channel through the atmosphere is used only for the single-camera modification of the TV system installed in inaccessible places, and also in places where it is impossible or inadvisable to lay cabled, e. g., in subway stations and lobbies, and in other indoor areas. The range of transmission within the limits of direct visibility is 500-1000 m, and depends on weather conditions for outdoor installations.

The ILPN-108 emitter with average radiation power of 40 mW and frequency modulation limit of 200 MHz is used for transmitting video signal and control commands. The emitter is equipped with a three-lens objective to minimize divergence of the light beam. The photoreceiver has a single-lens objective. The radiation wavelength corresponds to the "optical window of transparency" of the atmosphere. In this version, the system can operate from a self-contained power supply. Low-power ILPN-102, ILPN-103 and ILPN-210 emitters with average radiation power of 1-5 mW and wavelength of 0.82-0.92 μm are used to transmit a signal when observing an object and the performance of work indoors. The POM-3 and POM-5 modules can be used with radiation coupled out through the objective of an interfacing unit. In all cases, radiation power suffices for transmitting video signal and control commands to a distance of 500 meters.

All semiconductor coherent emitters that are used operate in the infrared band, and therefore two-way tuning with the photocell is done at night or in a darkened room, using a night vision unit. For the sake of convenience in tuning, the emitters and photocells with objective lenses are mounted on identical devices that allow precision manual tuning in the horizontal and vertical planes at an angle of plus or minus 10°.

A high-intensity infrared booster emitter is installed with the TV camera in cases where an object has to be observed under conditions of limited visibility or poor

illumination. This gives a range of observation of as much as 150 meters in total darkness.

The receiving end of the TV system consists of a control console, radiation, fiber-optics, and two-wire channels for control command transmission, a video signal photoreceiver, a linear video amplifier, a distributor amplifier, supplemental hardware, and a video monitor.

The TV system is controlled entirely from the control console. The CC includes: a stabilized power supply, light display, control command coder, and coded command signal amplifier.

A stabilized power supply provides the required voltage for all the aforementioned components of the CC and the receiving end of the TV system, and also the transmitting end in the case where there is no line voltage at the installation point. Commands are transmitted by pressing the appropriate button on the CC panel. When the locking "On" button is pressed, line voltage of 220 V is sent to the power supply and video monitor, and at the same time a potential of 12 volts is sent over the two-wire control command transmission line to turn on the stabilized power supply on the main camera.

When using the FOCL and radiation communication channel, the power supplies of the main camera and the camera with AU analogous to the main camera are continuously energized on stand-by. The camera number is selected by pressing the corresponding button. In this case, a coded signal goes through the two-wire command transmission channel to the decoder input, and when a radiation channel or FOCL is being used, it goes to a photocell, and from there through an amplifier to the decoder input. The decoded signal operates a controller that turns on the television camera by sending voltage from the stabilized power supply of the AU, or through a two-conductor line from the power supply of the CC. At the same time, video signal output from this TV camera is connected to the appropriate video information transmission channel. The TV camera is turned off by pressing the "Off" button, after which another camera can be turned on. The coded signal from the CC via a decoder switches the outputs of all controllers of the AU to terminals of the appropriate plug to which the selected camera is connected. Control of television cameras with different aiming units has been described above. Standard monitor circuitry is used for transmitting direct current and control commands over the two-wire line, and the video signal over coaxial cable.

The light display unit shows the "on" status of the TV system, the number of the active camera, and the type of operation. Aiming of the camera in the vertical and horizontal planes is done by pressing the appropriate non-locking button, i.e., execution of the command continues only as long as the button is held down. The optical attachment and glass wiper are operated the same way. The cameras can be automatically scanned in these planes by pressing locking buttons. In this case, the camera is reversed by operation of end microswitches that limit the angle of turn. Control command coding is similar to that used for the monitor.

A supplementary AU as far away as 300 meters can be connected to the main AU by a four-conductor cable, along with a supplementary monitor and VCR through a distributor amplifier. The supplementary AU operates only when the main AU is disconnected, and it is dependent on the main unit. When the main AU is activated, the supplementary AU is cut off. Depending on conditions of placement of the receiving end when transmitting control commands and receiving a video signal over FOCL, the transmitting optical module (POM) and video signal photoreceiver can be placed next to the CC, and can be moved outside of the room.

The modular TV system has been developed for night operations on railroads under conditions of strong electrical interference; it has enhanced sensitivity under low-lighting conditions. The system is designed around a new semiconductor component base with the use of semiconductor coherent emitters and fiber optics, enabling considerable simplification of construction, reduction of cost, electric power consumption, and expenditures on installation, repair and upkeep, and enhancement of interference immunity, reliability and service life as compared with conventional ITV.

Tests that have been done on railway transportation facilities with normalized nighttime illumination of at least 2 1x have shown good results. Use of the TV system at night increases labor productivity in commercial car inspection, checking track occupancy, observing locomotive shunting operations, humpyard classification of trains, reading car numbers, overseeing sorting yards and passenger platforms, subway escalators and halls, organizing security guard operations in watching freight handling and goods, overseeing container and freight platforms, warehouses, cashier and distribution rooms, and so on. Low power consumption allows operation of the TV system from a self-contained power supply when there is no power line, e. g. with installation in remote areas.

The described TV system may find wide application in various sectors of the national economy where work is done at night, and can also improve labor productivity in enterprises that have work sections with low lighting.

Robot System for Assembling Flange to Spider of Vehicle Cardan Shaft

18610002a Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 88 pp 1-2

[Article by B. M. Lovket, engineer]

[Text] Robotization of assembly is given a considerable role in raising labor productivity and improving the quality of goods produced. Extensive use of automatic

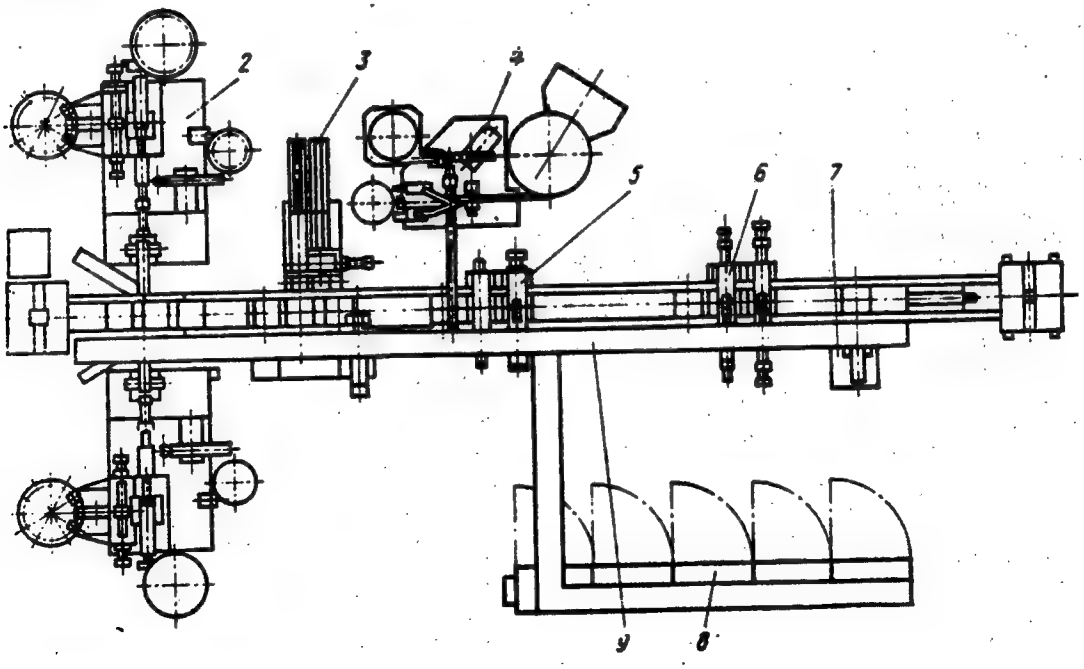
manipulators and industrial robots enables development of robot systems with configuration depending on the construction of the item to be assembled, the production program, and the specifics of technological organization of the assembly process.

In developing the robot system, research was done on the designs of all cardan shafts produced by Soviet industry, technological processes of shaft assembly, production organization, and also the technical characteristics of the equipment used. Analysis showed that the maximum number of technological and design features are combined in assembly of a flange with a spider that is part of the cardan shafts of the GAZ, ZIL, KAZ, KamAZ, UralAZ, MAZ and KrAZ trucks. Based on the consultant data, a technological process was developed for assembling the flange to the spider, providing for sequential execution of the following operations: assembling the spider with four seals and a plug; inserting the spider into the flange; assembling the bearings with rings, and lubricating them; pressing the bearings; assembling the cover and stopper plate with two bolts; starting and tightening the bolts; bending out the "tabs" of the stopper plates; removing the assembled units.

Technical Specifications:

Capacity at loading factor of 0.8, parts per hour	286
Drive of mechanism	Pneumatic, electromechanical electrovibration
Feed and orientation of parts	Automatic, manual, from magazines, vibrochutes, from container
Type of industrial robots used	MP-9S, USB 10
Number of robots	11
Compressed air consumption, m^3/hr	14
Line voltage, V	390 plus 10% or minus 15%
AC frequency, Hz	50 plus or minus 1
Overall steady-state power, kW	10
Dimensions, mm	9620x5466x2080
Mass, kg	12,000

The system (see figure) includes: devices for assembling the spider, assembling the spider to the flange, assembling bearings, assembling lock; devices for conveying



Robot system for assembling flange to spider of cardan shaft: devices for -- conveying (1), assembling spider (2), assembling spider and flange (3), assembling bearings (4), pressing bearings (5), assembling lock (6); 7 -- manipulator; 8 -- electrical equipment; 9 -- pneumatic equipment

and pressing bearings; and industrial robot; electrical and pneumatic equipment systems.

The conveyer used for asynchronomous transportation of the follower carrying the parts in accordance with the technological processes of assembly, consists of mechanisms for lifting, lowering and locating, a stopper device, upper and lower branches with drives.

The device for assembling the spider with seals and plugs includes magazines for spiders, mechanisms for supplying seals and plugs, USB 10 manipulators, MP-9S robots, mechanisms for turning the plugs, and monitoring mechanisms.

The device for assembling the spider to the flange sets the flange on the follower, picks up the spider, feeds it to the next stations and mates it with the flange.

The device for assembling bearings connects the bearings to the rings and dispenses lubricant. This unit includes: a rotating table, an MP-9S robot, a vibrating bin for feeding the rings, a tank with lubricant, dispensers, mechanisms for feeding the bearings and inserting the ring in the bearing, a sealing mechanism, and a chute.

The device for pressing bearings consists of mechanisms for raising and lowering the bearings, and pneumatic cylinders for feeding, orienting, preliminary and final pressing and clamping.

The device for assembling the lock does the final tightening on the bolts, and locks them by bending the "tabs" of the stopper plate.

The assembled items are taken off my manipulators that include mechanisms for rotating, mating, and horizontal displacement, as well as grabs.

The system is controlled in the setup, cyclic and automatic modes by a standardized electrical automation unit that is part of the electrical equipment system.

The pneumatic equipment system, which includes pneumatic cylinders, tubing, and monitoring and adjustment equipment provides for transporting mechanisms in the assigned mode.

The spider is assembled with seals and plug as follows. Spiders that have been manually put into the cassette of the magazine are fed to the pickup zone by the manipulator. From here the manipulator transfers them to the seal assembly station and places them on flats. At the same, time, the seals that have been oriented in the prescribed position (improperly oriented seals are dumped into a vibration bin) are transferred through helical chutes to a station where they are to be pressed by pneumatic cylinders. The manipulator then lifts the spider, turns it through 90° about the vertical axis, and places it on flats again for pressing seals on another pair of pins. The presence of a seal on pins of a spider is checked by sensors in the manipulator grab. Following pressing of the seals, the spider is transferred to the plug tightening station. A plug that has been oriented in a vibration bin is first fed to a receiver unit, and the industrial robot is then shifted to the control station; only after this is the socket set on the plug head, driving it into the spider. A second manipulator places the preassembled spiders on the follower bed (spiders lacking seals and plugs are dumped into a reject bin).

The spider is assembled to the flange at two stations: at the first station, the spider is picked up from the follower, and the flange is placed on it; at the second station, the retrieved spider is mated with the flange. Manipulators assembled from USB 10 modules set the flange on the follower, and also pick up the spider from the follower and mate it with the flange.

At the next station, the bearings are set on the preassembled unit. On the delivery table they are unpacked, placed bottom-side down, and then shifted to a continuously rotating turntable from which they go to a chute that terminates at a feed mechanism. Here the industrial robot seizes two rings, lubricates them, and places them on the device with the bearings. The assembled and lubricated bearings are fed to a preliminary pressing zone, where they are oriented in such a way that the slot on the bottom assumes a vertical position, while the spider is being oriented relative to the flange. Pneumatic cylinders are used for preliminary and final pressing of the bearings.

Assembly of the lock and starting of the bolts in the flange holes is done by hand; final tightening and locking of the bolts is done by socket drivers and mechanisms for bending the "tabs" of the stopper plate. A manipulator picks up the assembled pieces from the follower and places them on a gravity conveyer.

Sensors check the end positions of the mechanisms, as well as the course of performance of all operations of the assembly process.

Introduction of the robot system at the Kherson Cardan Shaft Plant has increased labor productivity and improved working conditions.

UDCΔ65.015.23:002.53

Microprocessor System for Gathering and Imaging Technological Information

18610002c Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 88 pp 16-17

[Article by V. I. Arabadzhi, V. A. Druzhinin, S. V. Kochkin and I. I. Shnur, engineers]

[Text] At the Special Design Office of Precision Casting Machines of the Moldavian Tochlitmash Production

Association, the SOTI system has been developed for gathering and imaging technological information. The system is designed for imaging information about the course of a technological process with output of text and graphic information on the screen of an IMG-1-02 gas-discharge graphics display.

The system is made up of a microcomputer, analog-digital converter (ADC), technological parameter display (TPD), control console (CC), analog signal sensors, and discrete signal input (DSI) module.

The microcomputer is based on the 16-bit K1801VM1A microcomputer, and it inputs, processes and outputs information in accordance with systems software and user programs recorded in a programmable read-only memory (PROM). The total capacity of computer memory (RAM) and PROM is 28K words. A three-channel programmable 16-bit timer based on the KR580VI53 microchip provides timer interruption of the processor and initialization of two requests for radial interrupt. the K589IK14 interrupt controller handles seven radial interrupt requests.

The ADC module converts unipolar analog input signals coming from measurement sensors to 10-bit parallel binary code.

Parameters of analog input signals to the ADC: 0-10 VDC, 0-20 mA. The module is designed around the K1113PV1 single-chip ADC. Conversion time no more than 35 μs. Relative conversion error no more than 1 percent. Number of input channels 16. Electrical decoupling between analog and digital circuits is used in the module to improve interference immunity.

The TPD module displays information in graphic and text form, and provides for recording and storage of information in the RAM of the module. Information is displayed on the IMG screen.

The working field of the screen measures 100x100 mm. The color of fluorescence is red-orange. Number of information elements of the display: 100 along the x-axis, 96 along the y-axis. Size of RAM: 1K 16-bit words. The TPD module is based on a board for interfacing with the IMG display, and a register board.

The interfacing board performs the function of reading and writing information from microcomputer RAM to the RAM of the TPD module, and scanning the contents of the module RAM on the screen. Reversible scanning is used for reliable ignition of display segments.

The register board, based on the KP580IK55 programmable I/0 unit, outputs information from the TPD module RAM to the screen.

The control console (Figure 1) inputs information to the microcomputer, and shows it on a seven-segment eight-place vacuum-luminescent display. Information is entered

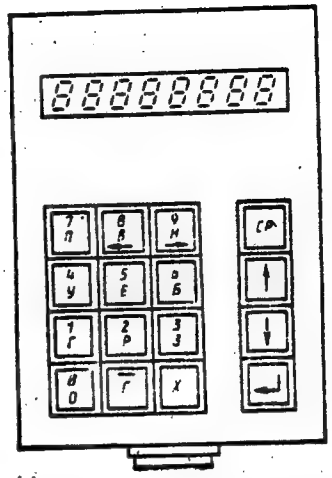


Figure 1. Control Console

on the CC by 16 keys, each of which can be used to enter several characters. The value is selected by a program, and is context-sensitive. The information is shown on the CC display. Four-bit parallel code is used for interchange between CC and microcomputer. The microcomputer polls the console keyboard with a period of 10 ms.

The discrete signal input module is designed for receiving DC signals of positive polarity at plus 24 V, and has 16 channels. The module provides electrical decoupling between input circuits and the logic section of the module, and displays the status of the input circuits.

Any measurement transducers that have standard GSP [State System of Industrial Instruments and Automation Equipment] output signals can be used as sensors in the SOTI system.

SOTI can: convert analog signals to binary code, and write it to the working storage (RAM) of the microcomputer; output as many as 15 graphs simultaneously to the IMG screen; change scales of coordinate axes; shift a graph horizontally with display of the absolute value of time displacement from the coordinate origin; shift graphs vertically relative to each other; control the duration of measurement of an investigated process (from 0.05 to 10 s with a step of 0.05 s); output the coordinate so any point of a graph in absolute units; mathematically process information obtained from sensors by user-provided programs; display text information on the IMG screen.

SOTI has three modes of operation: signal input from sensors, output of text messages, and display of graphic information. The first mode can operate in conjunction with one of the others.

To implement all the aforementioned functions of SOTI, a software package in SI high-level programming language has been developed that is recorded in the programmable read-only memory (PROM) of the microcomputer. The main programs of this package are:

control console service; graphics generator; character generator; the menu through which the operator communicates with SOTI.

Programs for sequential sensor polling and mathematical processing of the resultant information are written by the user for each specific case. The user also defines the content of text messages.

When a key is pressed, the console service program generates the code of this key and displays the corresponding character on the console panel. Pressing the "Mode" key followed by the mode number loads programs that operate in the selected mode.

The graphics generator uses a 100x82 point section of the screen. A coordinate of the graph is generated in accordance with a prescribed scale with respect to the y-axis, and a constant of vertical displacement. If the result fits into the provided field, a segment of a column is computed that is equal to the displacement from the preceding point to the current point. Otherwise, the column is lit to the top of the field. A memory segment is allocated in RAM for each graph.

The character generator can print 192 characters on the screen (12 lines by 16 columns). Character size is 5x5 points. The program generates all characters of the Russian alphabet, digits from 0 to 9, and the symbols + - = . , ; / : and space. If necessary, the number of characters used can be increased by adding the necessary symbols to the table.

SOTI organizes textual information by pages. The maximum number of characters per page is 192. The key marked "enter" on the CC is pressed to move to the next page. The number of pages of text is determined only by user memory.

The menu system in the third mode enables selection of the working graph, scaling, shifting and deleting graphs, read-out of graph coordinates, and setting the time of measurement of a process to be studied. The menu system si open, allowing the addition of new functions when necessary.

To select an operating mode, the user presses the "Mode" key on the CC, followed by the key with the number of the required mode.

MODE 1. A constant equal to 1/500 of the prescribed time of measurement of the process is recorded in the programmable timer. Through set time intervals, the timer generates an interrupt signal, at which point the number of the selected channel is recorded in the command and status register (CSR) of the ADC, and the "Start ADC" bit is set.

Following completion of conversion, the ADC loads a "Ready" code into the CSR, and generates an interrupt signal. On this signal, a 10-bit binary code from the output register of the ADC is loaded into RAM in the microcomputer. This sequence of operations is repeated until all 500 points of the graph have been read.

MODE 2. User-defined text information is output to the IMG screen.

MODE 3. Upon entering the third mode, the main menu is displayed on the screen, each line defining a certain operation. The required line is selected by moving a highlighter that is a reverse video of the given line. The highlighter is controlled by the "up arrow" and "down arrow" keys of the CC. Pressing the "enter" key exits to the selected sub-mode, which may also have its own menu, and so on. The number of lines of the menu and the operations performed are user-defined.

Let us look at the operation of the SOTI system as used for measuring the technological parameters of a die casting machine (DCM).

The DCM is equipped with sensors for: the path of the press punch; column tension; pressure in the hydraulic system, accumulator, piston end, and rod end; temperature of die and melt.

During DCM operation, graphs are plotted for the velocity of the punch, and the pressure in the rod end. The die and melt temperature, closure force, final pressing force, time of pickup of multiplication pressure, and amount of metal dispensed are determined once per working cycle of the DCM. The average rate of the second pressing phase is computed on the basis of data about the path and time of movement of the punch.

By pressing the "mode" key followed by the key with the mode number, the operator selects the required working mode.

In mode 1, readings of the aforementioned sensors are taken.

In mode 2, the screen displays the names, prescribed and actual values of the monitored parameters (Figure 2). The highlighter appears on the top line of the screen. By moving the highlighter to the required line, one can observe the change in value of the selected parameter at each stage of DCM operation. The required text information in the given case takes two pages. To go to the next page, the "enter" key is pressed.

Upon switching to the third mode, the menu appears on the screen. The required sub-mode is selected by the highlighter. Suppose that the rate graph has been selected. After pressing key "left arrow", the graph appears on the screen. A sub-menu line is shown on the first line of the screen. To go to the next line of the sub-menu, the "down arrow" key is pressed, and to go to the preceding line, the "up arrow" key.

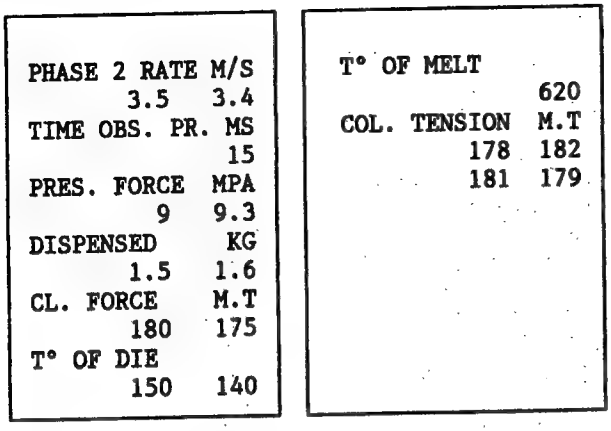


Figure 2. Imaging of Technological Parameters

In this case, the menu consists of the lines:

1. **Vertical scale.** When the device is first turned on in the right corner of the line, the scale is set at 1:1. Keys "left arrow" and "right arrow" are used to change the scale. Scales of 1:2, 1:4 and 1:6 are possible.

2. **Horizontal scale.** The initial scale is 1:5, i.e., each fifth point of the graph is shown on the screen. Scales of 1:1, 1:2 and 1:4 are available.

3. **Shift.** Pressing the "left arrow", "right arrow", "up arrow" and "down arrow" keys on the CC moves the graph left, right, up and down respectively.

4. **Cursor.** In this mode, a cursor in the form of a vertical line appears that can be moved by pressing the "left arrow" and "right arrow" keys. As the cursor moves, a menu line shows the absolute value of the coordinates of intersection of cursor and graph.

5. **Delete.** After pressing the "enter" key, the graph is deleted from the screen.

6. **Exit.** The preceding menu is accessed by pressing the "left arrow" key.

The system is open for expansion of functions. By appropriate programming, the values of parameters can be maintained at set levels, measurement results can be statistically processed, communication can be established with a higher-level computer, and so on.

Using SOTI enables rapid selection of optimum equipment operating conditions, and on-line representation of the course of a regulated process in the form of tables and graphs. The use of SOTI obviates the need for a large number of meters and light panels, facilitating the work of the operator.

UDC 621.762.004.14

Metallurgy of the Future

18610006a Moscow MASHINOSTROITEL in Russian No 6, Jun 88 pp 4-8

[Article by A. V. Sherstogatov, engineer]

[Text] The "Main Directions of Economic and Social Development of the USSR for 1986 and Beyond to the Year 2000" call for tripling production of items of powder metallurgy methods by the end of the five-year plan. The exceptional importance of this work was stressed by the Twenty-Seventh CPSU Congress.

All machine building sectors of the national economy are expanding research on powder metallurgy methods to put them to more effective use. This research is being done in the cutting tool industry by the Special Design Office of Powder Metallurgy [SKTB PM] of Armstanok Scientific Production Association (Yerevan). The items and technological processes that they have developed have been given awards by the Exhibition of Achievements of the National Economy of the USSR, and have been shown several times in exhibitions outside of the Soviet Union.

The association has put about 80 iron-graphite powder composition items into experimental production. The annual output of the items is 75 metric tons. Metal powder items are being delivered to 15 plants of the machine building industry, and 10 republic enterprises of other sectors. The economic effect due to introduction of developmental projects in experimental production facilities will come to 2 million rubles by the end of the five-year plan.

During the past five-year plan within the framework of a Soviet-wide comprehensive target program, an original resource-saving technology was developed for processing high-speed steel chip waste into high-quality stock for cutting tool production. An experimental production facility with capacity of 100 metric tons per year has been set up on the basis of this technology.

Technology without parallels in the USSR or abroad solves problems of recycling waste from machining of scarce steel (including the tungsten, molybdenum, vanadium and chromium used in these steels), as well as problems of improving the characteristics of high-speed tool steel during reprocessing.

Saving material resources by total comprehensive use of existing sources of raw material, finding new and unconventional forms of raw material, and development of waste-free production facilities, are important tasks that have been placed before the national economy. Machining in machine tool building enterprises today yields

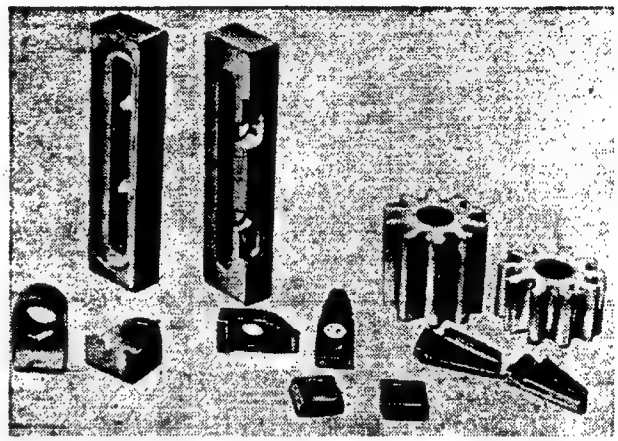
metal chips massing about 30 percent of the mass of the items machined, most of this waste coming from lathes and milling machines. Wastes amount to 100-120 kg per shift, which adds up to roughly 10 million metric tons in a year. It is an impermissible extravagance to shrug off such losses. Effective methods are needed for processing wastes. The most widely used method, and the only one available until recently, has been remelting. However, this has several considerable disadvantages. Among other things, the yielded mass of material suitable for further use is only one fifth of what is charged into the furnace. Only 200 kg of usable metal may be obtained from 1000 metric tons of chips [sic]. Another problem with this method is the poor quality of secondary castings, since the furnace burns out the alloying components "responsible" for all valuable properties of the steel. Thus, "second grade" material is obtained that is unsuitable for producing a large class of goods. Therefore, efficient use of metal wastes from machining has remained a timely problem. In solving it, specialists of the Department of Prospective Development of SKTB PM under the supervision of K. T. Davilyan have worked out a method for directly reprocessing chip wastes of alloyed structural steels (such as 18KhGT, 40Kh) into nearly pore-free powder-metal steels. This method of recycling chips into powder without an intermediate melting operation is distinguished by greater purity, as well as near 100-percent use of alloying elements. Replacement of high-temperature heating with pulverization has retained all valuable alloying additives while eliminating losses in mass. As of now, the term "chip metallurgy" is being used to designate the [new] area in the field of producing metal powder.

There are a number of nuances that influence the quality of items. Consideration is taken even of the kind of chip (coiled or ring-shaped, short or long, and so on). Of considerable significance is the time spent on the process and the quality of pulverization. Crushing is fairly economic if the material is brittle. However, steel has high ductility, and undergoes plastic deformation in the mechanical crushing process. Therefore the expenditures of energy on reducing steel to powder are more greater than for brittle metal. Consequently, the chips must go through preliminary preparation: cooling or chemical heat treatment.

The improvement in quality and reliability of machines and mechanisms, elevation of productivity of equipment, and intensification of metal-working process depend to a considerable extent on the quality of various protective coatings.

Today's industrial technology for applying coatings and reinforcing the surfaces of machine parts by conventional methods (galvanic, diffusion saturation, chemical heat treatment) does not always result in the required working properties of the surface of parts. The necessity of using carbides, nitrides and borides as coating materials dictates the use of fundamentally new methods of applying coatings.

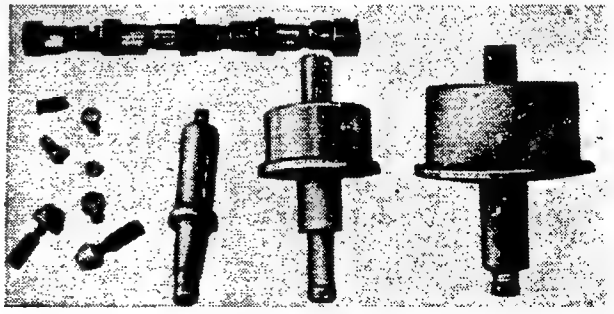
An experimental-industrial laboratory section has been set up at SKTB PM where progressive methods are being studied for applying coatings by gas-thermal and vacuum ion-plasma methods, and technologies are being developed for applying coatings of new kinds to specific parts of machines and mechanisms by a special device: the plasmatron.



Powder-metal parts of structural designation developed by SKTB PM of Armstanok Scientific Production Association that are being delivered in quantity to plants of the sector

One example of effective use of restorative processes, in the opinion of Deputy Director of SKTB PM A. A. Sagatelyan, is work that has been done by office colleagues at Nairit Scientific Production Association. In imported equipment that had outlived the warranty, key parts failed, and there were no replacements. The plasmatron came to the rescue: a handy mobile unit allowing application of a layer of wear-resistant metal up to 4 mm thick, completely restoring and even improving the service properties of the parts. Tests have shown that the service life of parts, and accordingly of equipment, is quadrupled on average.

Another facility can be used for detonation spraying of coatings. The principle of this unit is to use a detonation wave generated in exploding gases. A significant advantage of the detonation method is that the surface being covered is not strongly heated during treatment, precluding temperature strains of workpieces.



Machine parts restored by various methods of applying wear-resistant and reinforcing coatings

Coatings can be applied on parts (hardness less than or equal to 60HRC) of any configuration with the exception of small-diameter internal surfaces. Thanks to the high velocity of the particles being sputtered, detonation coatings have a density close to that of the monolithic material, and excellent adhesion, considerably exceeding that of other methods of high-temperature sputtering.

The high service properties of coatings applied by methods of detonation spraying increase the service life, durability, and corrosion resistance of parts and subassemblies by a factor of 5-10, and in some cases, 20-30. Detonation coatings have performed well in parts subjected to the actin of high temperature and shock loads. For example, replacing hard alloy press punches with steel punches that have been detonation-coated with hard alloy based on tungsten carbide extends their service life by a considerable factor.

The use of detonation sputtering is very effective for reinforcing vehicle engine parts.

Another area of research is the investigation of vacuum sputtering processes. Outworn cutting tools are restored in a [vacuum] chamber. "Renovated" milling cutters, lathe tools and broaches acquire enhanced stability. Research on the technology of applying wear-resistant and reinforcing coatings has been supervised by F. M. Boduryan.

Considerable attention is being given to enhancement of the quality of tool stock and cutters, saving scarce tungsten-containing materials, and organizing large-scale production of new kinds of tools.

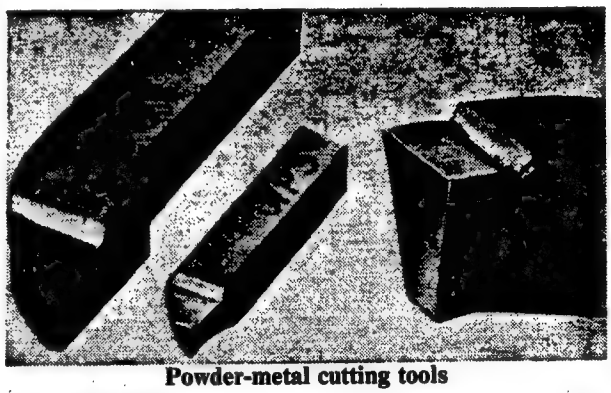
Prospective tool materials that are not industrially produced and used are carbide steels: a new class of materials that are a composite of alloyed tool steel with uniformly distributed carbides—refractory materials. Carbide steels have unique properties: the hardness and water resistance of hard alloys; the strength and toughness of alloyed steels. They are more easily heat-treated than hard alloys; they can be used to make cutting tools, hot and cold stamping tools, molds, and dies or cold and hot extrusion. The stability of carbide steel stamping tools is 10-20 times that of similar tools made of conventional tool steel.

It is advisable to use carbide steels when making tool blanks or stock for structural parts that are close in shape and size to the finished items. SKTB PM has developed a technological process for fabricating blanks of carbide steel items produced by crushing ships in milling with the addition of titanium carbide.

The area of effective use of the aforementioned materials is for items such as support plates and tips of cutting tools. In particular, carbide steels are being used in place of VK15 or VK20 alloys for making the support plates of cutting tools. This solves the problem of saving tungsten-containing hard alloys. Replacement of the backing plate of cutting tools alone gives a yearly savings of 30-40 metric tons of hard alloys. Research on development of technology for producing carbide steels has been done under the direction of G. Z. Charchyan. The annual economic effect from introducing them is several million rubles.

Development of modern equipment requires the creation of antifriction materials capable of prolonged operation under conditions of high speeds, pressures, and temperatures, in vacuum and in aggressive media. Armstanok Scientific Production Association has developed a new series of antifriction materials based on iron with the use of solid sulfide, phosphide and selenide lubricants designed for operation in moderately and heavily loaded components under conditions without lubrication, or with a limited supply of lubricant at high sliding speed and high temperatures.

These antifriction materials are used as substitutes for nonferrous metals (bronze, babbit), and are intended for making journal bearings, seals, inserts, and other parts. For example, use of this technology for making powder metal parts in place of bronze at Cherentsevanskiy Forklift Plan will save more than 60 metric tons of scarce metal.



Powder-metal cutting tools

The appreciable increase in production of cutting tools with disposable tips brings considerable complications to the problem of producing a wide range of fasteners for tool parts in large series. Machining these items of complex configuration is very labor intensive. Moreover, the coefficient of utilization of metal in producing them does not exceed 35-40 percent. Workers at SKTB PM have proposed nearly waste-free fabrication of fasteners from powder composition by hot stamping. The process can be automated, which is essential for large-series production.

An automatic production line with robot system has now been introduced at the experimental production facility of Armstanok Scientific Production Association for experimental industrial production of cutter fasteners destined for Kharkov and Tbilisi cutting tool plants.

Further expansion of the area of application of powder structural items in various sectors of industry requires a qualitative jump in the development of technology for fabricating sintered items of complex shape with

improved properties. This applies in particular to machine tool construction, where machine parts in most cases must have high strength characteristics, and a lot of parts are used with complex configuration, such as cams, forks, and gears. Dynamic hot pressing or stamping is the most promising method of making powder metal gears for operation in heavily loaded components under high dynamic loads.

Powder metallurgy has been called the metallurgy of the future. By the end of the five-year period, enterprises of the Ministry of the Machine Tool Industry are to increase the production of metal powder and items made from it by a factor of 20 as compared with 1986.

UDC 621.9.06.52

Non-Contact Measurement and Automatic Adjustment of Tension and Takeup Speed

18610002d Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 88 p 21

[Article by V. S. Markosyan, Z. K. Khachikyan and T. K. Saakyan, engineers, and G. L. Kotanidi, candidate of technical sciences]

[Text] A disadvantage of takeup mechanisms, where technological parameters are being monitored and adjusted by special mechanical or electromechanical devices, is direct contact between the sensing elements of these devices and the materials being wound, which leads to surface damage, and in most cases increases material breakage, reduces the service life of the sensing components, increases errors, reduces the accuracy and reliability of adjustment and stabilization of technological parameters, lowers the productivity of process equipment, and is generally detrimental to further technological handling. All this has a negative effect on the quality of goods produced.

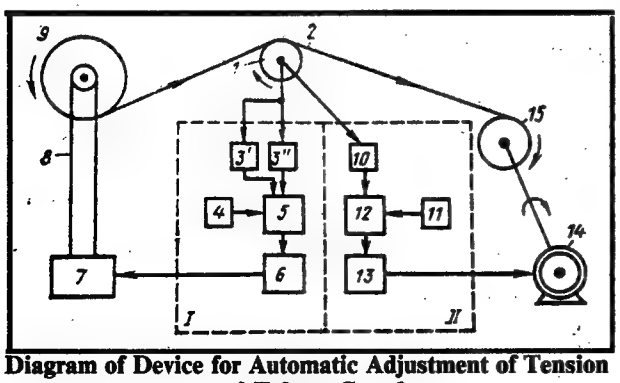


Diagram of Device for Automatic Adjustment of Tension and Takeup Speed

The Avtomatika Scientific Production Association has developed a facility (see the diagram) for automatically adjusting and stabilizing tension and linear velocity when rolling up long goods with a noncontact method of measurement. The unit is a system with two self-contained channels: for adjusting the tension of materials (I) and for adjusting linear velocity (II).

A measuring roller 1 on the takeup mechanism is used as the sensing element of overall tension and linear velocity of takeup. The roller is turned by the material 2 passing over it.

The working principle of channel I consists in using summing amplifier 5 to compare amplified signals from sensors 3' and 3" (strain-gage resistor force measuring sensors kinematically coupled to the bearings of the measuring roller), with a master signal from control point adjustment 4 that sets the tension. Depending on the sign of the mismatch signal at the amplifier output, control unit 6 operates on actuating mechanism 7 that tightens or slackens brake belt 8 of feed reel 9.

The working principle of channel II consists in using summing amplifier 12 to compare the signal from sensor 10 (an angular velocity sensor with shaft coupled to the shaft of the measuring roller) with a master signal from control point adjustment 11 that sets linear velocity. Depending on the mismatch signal at the amplifier output, control unit 13, through pulse-phase control of a thyristor converter, adjusts the speed of electric drive motor 14 of takeup reel 15.

By setting the control point adjustments of tension and linear velocity in accordance with the specific material being handled and with allowance for technological particulars, tension can be continuously adjusted in a range of 50-5000 N, and linear velocity in a range of 20-100 m/min. The device provides automatic regulation (for purposes of stabilization) of the set values of these parameters within the aforementioned ranges in the following way: when tension increases (increased force of the material on the measurement roller), the braking force of the feed reel decreases, and when tension decreases, the braking force increases, thereby stabilizing the set tension within a permissible accuracy of 5 percent. As roll diameters change on the feed and takeup reels (or when there are perturbing factors), the speed of the electric drive motor of the takeup reels is adjusted to keep the speed of the measuring roller constant, stabilizing the set linear takeup speed within a permissible accuracy of 5 percent. Regulating time is 0.5 s, and overshoot is 5 percent. Tension setting does not change when the machine is stopped.

From the technical and economic standpoint, use of the described device is advisable in view of high dynamic and static accuracy of adjustment and stabilization of technological parameters with high quality of winding of goods.

The device has been installed on a cylinder warping frame at Yerevan Silk Combine imeni V. I. Lenin.

Introduction of the device has an economic effect of 2740 rubles.

UDC 621.9.06-529.001.13

Reasons for Delay in Effective Use of NC Machine Tools

18610006c Moscow MASHINOSTROITEL in Russian No 6, Jun 88 pp 36-37

[Article by M. K. Moysa, engineer]

[Text] Each passing year sees an increase in production of NC machine tools, and in their proportion of the total inventory of metal cutting equipment for basic production; for example, in enterprises of the Ministry of the Machine Tool Industry of Belorussia it amounts to more than 13 percent. Analysis shows that about 40 percent of items are being worked on NC machines, and 30 percent on universal equipment with manual control. This is because the demand of enterprises for this equipment is not being completely met. But if we analyze its use, it turns out that there are reserves in the form of idle time due to technical and organizational reasons, amounting to about 20 percent in enterprises of the Ministry of the Machine Tool Industry of Belorussia in 1985, of which more than 9 percent was from organizational causes. When appropriate operation of equipment has been organized, it will be equivalent to putting 190 NC machine tools into operation in a year. With respect to technical causes, down time can be attributed to a number of objective factors that do not depend on enterprises. This is not the case for organizational causes. The enterprises themselves can eliminate down time of this kind by timely efficacious action.

However, it would be wrong to consider the introduction of machine tools without considering their technological capabilities. As an example, let us analyze the lathe group, which makes up more than 50 percent of the total inventory of NC machine tools. Thus, it is impossible to evaluate the advantages of models 16K20F3 and 16K20T1 series produced machines without including their mutual relation to previously used 1336M, 1A341 and 1A341Ts turret lathes that performed well in enterprises of the Ministry of the Machine Tool Industry and other sectors of machine building. These machines were equipped with 12- and 16-station turret heads supporting any combination of axial and radial tools for machining parts (sequential and combined). They were equipped with a set of normalized tools that could be supplemented by special tools where necessary.

Analysis of the advantages and disadvantages of the aforementioned NC machine tools, as well as other models, shows that instead of 4-station tool holders, they are equipped with turret heads that can accommodate six tools for outside machining. However, these machines are designed for machining both between centers and in a chuck, where use of an axial tool (drill, counterbore, reamer, tap, and so on) is mandatory. Therefore, the NC machine tools have been additionally equipped with holders for an axial tool that cover two stations in a setup, and consequently limit the technological capabilities of the machines. What must be done if a precision hole is to be machined, where the standard arrangement would require as many as four axial tools? For this purpose, the plant efficiency experts have come up with a more effective design of a holder for an axial tool that takes up only one station when set up in a turret head.

Besides, the design of existing turret lathes precludes the use of holders in which tools could be set up for combined machining. The solution of this problem represents a reserve for growth of labor productivity, i.e., the time has come to find a way to use equipment for combined machining on NC tools. Combining machining methods will enable equalization and balancing of cutting forces, reduce the number of changes, shorten the time that cutters are in contact with the workpiece, and extend tool life. Putting cutters in a single holder improves alignment accuracy, the precision of the surfaces being machined, and increases productivity. The use of combined methods will bring an increase in the coefficient of equipment loading and utilization of machine tool capacities by a factor of 1.5. Multiple-operation NC machine tools have the same problems. A standardized set of progressive auxiliary tools has now been developed for such machines. However, even in this set there are no combined tools. Moreover, the new set lacks tools for machining slots in parts of relatively great length designed for exit of a tool in subsequent finish machining. At the same time, multiple-operation machine tools that have a fixed spindle stop may be equipped with an attachment (cutter head) for slot shaping (patent No 1022781).

In our opinion, it would be proper for the All-Union Scientific Research Institute of Cutting Tools to develop an expanded standardized set of auxiliary cutting tools for multiple-operation machine tools with consideration of the particulars of machining that are encountered in machine building practice, and provide catalogs first for the manufacturing enterprise, and then for the consumer enterprise, in which technical specifications would be given for the required list of given tools when ordering new machines. In this way, machine tools could be outfitted with a rational complement of cutting tools suited to the existing range of workpieces, relieving enterprise tool cribs of useless stock, and saving materials and labor resources.

For purposes of more rapidly making NC machine tools "conventional" in production, a cutting tool support system has been developed over the past ten years.

Principles have been worked out for equipping NC machine tools in accordance with which every series-produced tool is provided with a set of cutting tools allowing it to be put into service immediately after installation. This tool set includes cutting tools used in machining practically every workpiece, or the most frequently encountered surfaces of a group of workpieces. The number of tools is figured on the basis of performing starting and setup jobs, and at least six months of service to the consumer. This tool set should include tools of high-productivity designs that support introduction of progressive machining arrangements, including the rotary cutting method.

At present, there is a certain process stock of cutting tools that provide the capability of making higher-quality tools, enabling the use of augmented cutting conditions. Among these are:

—tools made of high-speed steels produced by powder metallurgy with 1.6-2.2 times the durability of conventional steel tips;

—tools with wear-resistant coating hardened on "Pusk," "Bulat," and "Yunion" facilities; their durability is enhanced by a factor of 2-4;

—grade V-3, VOK-60 and VOK-63 mineral-ceramic tools that triple or quadruple the cutting speed of wear-resistant grades of hard alloys;

—tools of ultrahard materials that increase cutting speed by a factor of 10-20, reduce the main time of machining parts by a factor of 2-10, speed up the process cycle by eliminating or reducing the time of execution of certain operations, improve the quality of machined surfaces, liberate workers, equipment, and production space. However, because of the high cost of these tools, they are being introduced slowly (according to data of enterprises of the Ministry of the Machine Tool Industry of Belorussia, the proportion of such tools does not exceed 2.2 percent of the cutting tools used for machining parts on NC machines). At the same time, without the introduction of high-productivity cutting tools, attainment of the projected efficiency of NC machines remains an unsolved problem.

Selection of the arrangement for machining has a considerable impact on labor productivity. However, even now tens of thousands of precision holes and hundreds of thousands of stepped fastener holes are being machined sequentially. If a number of recommendations are analyzed, they aim enterprises toward introduction of NC machine tools with the use of cutting and auxiliary tools of high-productivity designs, including tools for combined machining methods; paralleling this, GOST standards and technical guidelines call for using tool designs without allowance for requirements of intensifying machining of parts. Besides, items of main production are not adequately developed for technological adaptation, and have not always gone through metrological expert examination. Several recommendations on this issue have been made at the Scientific Production Association of the Experimental Scientific Research Institute of Metal Cutting Machine Tools (ENIMS); however, they are not always carried out in the design of new items, and in conversion of items for machining on NC tools.

Foreign and Soviet experience shows that when the requirements for technological adaptability of designs and standardization of machined surfaces are met, there can be a real reduction in the range of cutting, measuring, and auxiliary tools used for machining parts. ENIIMS [sic] Scientific Production Association and the All-Union Scientific Research Institute of Cutting Tools in cooperation with Zhalgiris Machine Tool Plant have done research on hardening cutting and auxiliary tools used for modules that are part of the Zhalgiris FMS. These tools are combined into standardized sets by sizes and types of machining with specification of augmented cutting conditions. The guidelines are in a desk reference that is indispensable to the programmer technologist. In future, analogous catalogs should be compiled for all technological groups of NC equipment for centralized support of enterprises that use NC machines. At the same time, the USSR State Bureau of Standards should study the makeup of coded setups, and permit specification of only their codes in technological operating charts.

It would be desirable for the All-Union Scientific Research Institute of Cutting Tools and ENIMS Scientific Production Association to make a more thorough study of the range of items being machined on NC tools, and to work on a catalog of cutting tools and auxiliary tools for all technological groups of the specified equipment, including tools designed for the combined machining method. The All-Union Scientific Research Institute of Cutting Tools should develop a combination cutting tool standard for the most widely used sizes of holes. In addition, a combined (stepped) reamer should be provided for machining precision open holes, and a standard should be developed, eliminating roughing and finishing operations from machining. In connection with the advent of more powerful equipment, it would be advisable in future to ascertain the feasibility of determining the actual loading factor of machine tools intensively (with respect of the power of the main drive motor of the machine), rather than extensively (with respect to time), which will enable them to be more effectively used, and to check out how the potential capabilities of the machines are realized in service. For purposes of more complete utilization of the normative service life of cutting tools, enterprises should organize tool restoration: averaged data show that it is possible to restore 25-30 percent of lathe tools, 20-25 percent of milling cutters, 10 percent of drill bits, and so on. Timely solution of these problems will enable more effective utilization of NC machine tools in enterprises.

UDC 061.22.658.012.6

Work by Ukrainian Machine Building Agency Advances Technical Progress

18610006b Moscow MASHINOSTROITEL in Russian
No 6, Jun 88 pp 8-9

[Article by V. S. Polonskaya, deputy chairperson of Kirovograd Regional Board of the All-Union Scientific and Technical Society of Machine Builders, and N. N. Petrenko, candidate of technical sciences, chairperson of the board]

[Text] One of the most acute problems of reorganization in machine building is to accelerate introduction of the latest advances into production. In this connection, a special role is given to practical directivity of scientific and technical information, and popularization of scientific and technical knowledge aimed at relieving bottlenecks and solving individual problems of enterprises.

Scientific and technical propaganda is yielding good results thanks to years of business contacts between the Regional Board (RB) of the All-Union Scientific and Technical Society of Machine Builders (VNTOM), the Kirovograd Interindustrial and Territorial Center of Scientific and Technical Information and Propaganda of the Scientific Research Institute of the UkSSR State Planning Commission, and the Kirovogram Scientific Research Department of the central Scientific Research Institute of Information and Technical-Economic Research for Tractors and Agricultural Machinery. In cooperation with these organizations, the board conducts scientific-technical conferences, seminars, schools of advanced experience, Specialist Days, Science and Engineering Days, film seminars, reviews, and relay competitions.

The system of coordination, planning and preparation of steps in scientific and technical propaganda is reflected in the summary plan of scientific-technical propaganda measures of Kirovogradskaya Oblast. To eliminate duplication of effort in propaganda and dissemination of scientific and engineering advances, leading production experience, and informational support of problems of scientific-technical progress in the oblast, a five-year four-way agreement with annual thematic supplements is set up between Kirovograd Scientific-Technical Information Center, the Regional Board of VNTOM, the Regional Council of the All-Union Society of Inventors and Innovators, and an enterprise. According to the agreement, the Scientific-Technical Information Center provides information service on topics of interest to the enterprise, takes charge of activities in a specified area of interest, makes arrangements for Exhibitions of Achievements of the National Economy of the Soviet Union and the Ukraine, and distributes information leaflets. The board assists with the conduct of contests, reviews, exhibitions of technical creativity, schools and teams for exchange of experience, excursions of specialists and innovators on creative tours, provides funding for these activities in whole or in part, publishes materials, pamphlets about leading production experience, offers procedural assistance in organizing competitions for personal creative plans, instructing specialists on organizing the work of public offices of technical information, and other public creative associations. The Regional Council of the All-Union Society of Inventors and Innovators offers procedural assistance in organizing work on invention and efficiency improvement, and in putting together materials for proposed inventions.

The enterprises are responsible for timely examination of informational materials provided, making reports about introduction of innovations introduced on the basis of the informational materials, and for transmitting documentation to the Scientific-Technical Information Center on scientific and engineering projects that have been put into production for consideration and use in other enterprises.

The thematic basis of the agreements is provided by yearly plans of the enterprise, giving a differentiated approach to various categories of enterprises, and ensuring completeness of the chain "problem-research-solution-introduction."

The RB holds reviews for better organization of work on propaganda, and the use of advances in science, engineering, and leading production experience in machine building enterprises and in organizations of the oblast.

The board holds Weeks of Science and Engineering in cooperation with the regional council of scientific and technical societies. For example, in 1987 a Week was dedicated to the problem of "Resources: Effective Utilization." A Machine Building Day in the context of the Week included reports and talks on the topic, and a market of scientific and technical ideas. Events included: an auction and exhibition of the best developments, scientific-technical advances that have been introduced into production and ensure savings of resources and waste-free production technology; an exhibition of unused or partly used waste, and a contest for the best way to use it; meetings of production specialists with scientists of institutes of the UkSSR Academy of Sciences, institutions of higher education, and planning institutes; a film festival of scientific-technical films. Interest was elicited by work with materials of a "Bank of Scientific-Technical Ideas" based on information about scientific developments on predefined problems.

In addition to traditional forms of work, the board holds film seminars on a variety of scientific and technical problems. For example, a film seminar was held in 1987 for supervisory and engineering personnel of Kirovograd plants entitled: "Acceleration of Scientific-Technical Progress: an Urgent Problem of the Day." Seminars of the same kind have been organized on the topics: "Using Robots and Manipulators, and Introducing Flexible

Manufacturing Systems in Machine Building," "Certification and Efficiency Improvement of Workstations, Team Forms of Labor Organization: Experience of Leading Plants."

Specialists showed an interest in an environmental protection exhibit organized on the initiative of the board, and commissioned for a seminar held on the same topic. Before the scientific-technical films, and during breaks in the showing, talks were organized by specialists on the topic of the seminar, during which participants exchanged opinions about technical films that had been seen. Topics of routine seminars are formulated on the basis of suggestions by enterprises, and in addition film festivals are organized in plants and departments at their request.

An effective form of propaganda that is used by the board is to hold relay competitions involving transfer of a relay logbook in two stages for a specified period in enterprises of the oblast. Data are entered in a specific blank form in the first section of the log about in-house developments on the topic of the competition, e. g., on mechanization, automation, and reduction of manual labor, specification of the principle of the innovation, a simplified diagram, sketch or photograph, the area of use, the economic effect, and the reduction in staff. The second section gives specifics about an innovation that has been adopted and introduced, with indication of all parameters and the source from which it has been adopted. When the period is up, the relay logbook is passed on to the next enterprise of the oblast, where similar information is entered. At the end of the first phase, the logbook returns to the first enterprise.

On the first phase, major emphasis is placed on proposed in-house projects, and enterprises advertise their suggestions. On the second phase, along with the new in-house proposals of enterprises, major emphasis is placed on introduction of adopted projects. After the two phases of the relay, the results are totaled, and the winning enterprises are determined both with respect to the number of proposals introduced, and with respect to adopted projects, and the economic effect of introducing them.

The board conducts three institutions of adult education in technical progress where the auditors go through course work and final exams with emphasis on solving practical problems. The results of many projects are finding application in production. In 1985-1987, the board trained about 12,000 people in courses, seminars, schools of leading experience, and institutions of adult education in technical progress.

The organization of scientific missions has become a major part of the board's work. The stress here is on studying facilities of leading experience, organizing excursions of specialists, and considering recommendations on introducing experience studied on the mission.

Problems of scientific-technical propaganda of the latest advances in science and engineering, and putting them into production more quickly are being studied by the board on a social basis in 77 sections; 41 economic analysis groups, 25 councils of scientific organization of labor, and 36 offices of technical information. For example, the regional section of production intensification has developed recommendations on transferring enterprises to a two- or three-shift work schedule and has distributed them to all machine building enterprises of the oblast. This section has held a conference seminar with supervisors of enterprises of the city, and consultations on finding reserves of enterprises, and on solving social problems in converting to a multiple-shift work schedule.

An interesting activity is a continuing two-year seminar of the regional section of sociological research aimed at advancing the professional knowledge of plant sociologists, of which there is a shortage in the oblast. Since February 1988, the section has staffed a continuously operating consultative station for specialists and managers of machine building enterprises to offer them procedural assistance in the investigation of social problems in raising production efficiency.

Working in affiliation with councils of scientific and technical societies of enterprises are sections for propaganda of technical knowledge, and public offices of propaganda and scientific-technical information. For example, working in affiliation with the Council of the Scientific and Technical Society of the Krasnaya Zvezda Seed Planter Production Association is a section for propaganda of scientific-technical knowledge whose members in 1986-1987 organized 26 exhibits of new in the technical literature in plant shops and departments, and held 49 special adviser days, 11 information days, and 11 plant specialist days.

The Regional Board of the Scientific Technical Society in cooperation with the Pridneprovsk Department of the Ukrainian Affiliate of the Scientific Research Institute of Labor has published overviews on "Experience in Introducing Team Forms of Labor Organization in industrial enterprises That Use the 'VAZ' System," and also analytical references on "Status and Outlook for Development of the Team Form of Labor Organization in Industrial Enterprises of Kirovogradskaya Oblast," and an annotated list of research projects done by scientists of Kirovogram Institute of Agricultural Machinery.

The Kirovograde Regional Board of the Scientific and Technical Society is part of a regional system for management of scientific-technical progress. The supervisory agency of the system is the regional coordinating procedural council on questions of scientific-technical progress and leading experience in sectors of the national economy, under the direction of the deputy chairperson of the regional executive committee. Within the framework of the regional system, the regional executive committee, regional trade council, regional organizations of the scientific and technical society, the All-Union Society of Inventors and Innovators, the Scientific-Technical Information Center, enterprises and

organizations with their own separate functions and problems complement one another, forming a complete system oriented toward a final result. The Kirovograd Regional Board of the Scientific and Technical Society of Machine Builders performs working and coordinating functions in this system.

UDC 62.50

Methods of Increasing Accuracy and Speed of Control Systems for Industrial Robots

18610433b Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 4, Apr 88 pp 14-16

[Article by N. V. Gorbachev, candidate of physico-mathematical sciences, and A. V. Safonov, candidate of physico-mathematical sciences]

[Abstract] Both accuracy and speed of control systems for industrial robots are increased by refinement of their mathematical models with a more precise description of their dynamics. A second-order differential equation is constructed which handles transients without overregulation and, accordingly, permits smooth movements of the automatic manipulator in the simplest case of only one degree of freedom. This equation of stable motion for position control is linear, if the electrical time constants of all electrical drive and control devices (motor, transducers, amplifiers) are disregarded. From the solution to this equation, which contains only one decaying exponential term in the mechanical time constant, an equation is derived for the control voltage meeting given constraints. The magnitude of the time constant defines the class of control, but it cannot be decreased to zero because of practical limits on the magnitude of the control voltage and owing to presence of dry friction. The control parameters can be optimized, however, the control speed being further increased by allowing discontinuity of the control function at switching points but a tradeoff with accuracy being unavoidable.

UDC 621.74:621.865.8.004

Designing Route of Transport Robot for Operation in Foundry

18610186b Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 88 pp 15-17

[Article by L. A. Ivanova, doctor of technical sciences, V. V. Simonov, engineer, A. L. Stanovskiy, candidate of technical sciences, and P. N. Goranov, engineer]

[Abstract] An algorithm for routing a transport robot in a foundry is outlined which, unlike known algorithms of global orientation, ensures most energy-efficient and time-economical bypassing of obstacles with a minimum memory capacity. This algorithm finds the equation for the straight line passing through both initial and final robot locations, then finds the points of intersection of its robot-target segment with the contour of each obstacle, and finally selects bypass on either left or right side in accordance with the shortest-path criterion. The algorithm has been programmed for computer-aided routing and was used for redesign of the Arsenal foundry imeni V. I. Lenin. Figures 2.

UDC 007.52

Automation of Plasma-Arc Cutting Process by Use of Industrial Robots

18610026 Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 7, Jul 88 pp 38-40

[Article by V. A. Maslov, engineer]

[Abstract] Industrial robots with automatic manipulators having six degrees of freedom are increasingly used for plasma-arc cutting of materials such as steels and aluminum or aluminum alloys. Electrical equipment with a 1000 A current rating designed for cutting 3-65 mm thick strip or plate is capable of cutting and shaping up to 160 mm thick blocks with a plasma arc, 80-300 mm long cuts being made at speeds of 200-1500 mm/min with currents of 150-220 A at a voltage of 170-190 V. The advantages of robotic plasma-arc cutting are a high degree of surface purity along the cut edges, a small heat-affected zone, a narrow slit, and a high degree of flexibility for diverse applications. Its shortcomings are the unsuitability for cutting sheet less than 3 mm thick and cutting materials which do not conduct electric current, also the impossibility of precisely locating the slit when the robot covers the entire trajectory or a part of it after the adaptation process. The essential requirements for robotic plasma-arc cutting are economic as well as technical feasibility, availability of automated transport facilities and automated other auxiliary technological equipment, and availability of wireless communication lines. Robotic production units already in operation are the Cybotek (U.S.) and the portable Air Transport G 100 (U.S.), the ZIS 995 or the ZIM 60-1 (GDR) with air or argon-oxygen plasma generator used at the Volvo truck manufacturing plant (Sweden), and the one developed jointly by SAAB-Torsteknik (Sweden) - Hobart Brothers (U.S.) - Yaskawa (Japan). The productivity of robotic plasma-arc cutting is 5 times higher than that of robotic gas-flame cutting, the cost of one complete production unit being about 600,000 rubles amortizable within 2 years at a production rate of 35,000 automobiles annually. Most effective is off-line control, both vector analysis programmed in BASIC language on Apple computer (U.S.) and the GRASP program of computer graphics (Nottingham University, UK) being available for controlling the motion of the plasma burner-nozzle relative to the work piece.

UDC 621.3.049

Robotized Technological Apparatus for Feeding Printed-Circuit Boards
18610186a Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 88 pp 14-15

[Article by A. A. Kurochkin, engineer, and V. K. Lukomskiy, engineer]

[Abstract] A robotic technological apparatus has been developed at the Kiev Special Design and Manufacturing Engineering Office for Medical Technology which feeds printed-circuit boards to a conveyor for etching and overlaying. The feeder-pedestal is mounted on the floor through height-controllable supports and carries on top an automatic manipulator which consists essentially of a cross-arm with suction grips. The number of grips is sufficiently large for loading the conveyor across its entire width and they can be spaced apart to match the size of board blanks. The cross-arm moves vertically for gripping blanks from the feeder table and dropping them on the the conveyor as well as horizontally for transporting blanks from the feeder to the etching line and back for reloading the conveyor. The feeder-pedestal carries also air preconditioning equipment for stabilization of the pneumatic drive system. The collector of finished boards has a similar pedestal structure. The robot eliminates tedious manual labor and saves over 8,800 rubles annually in production costs. Figures 1; tables 1.

UDC 621.865.8

Compound Working Element for Automatic Assembling Manipulators
18610433c Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 4, Apr 88 pp 16-17

[Article by I. G. Botez, candidate of technical sciences, I. A. Bostan, candidate of technical sciences, and L. A. Chupina, candidate of technical sciences]

[Abstract] The design of a compound working element for automatic manipulators of industrial assembly robots is outlined and shown, this element having been designed to grasp and transport a part, hold it during rotation of the arm, and feed it for auxiliary operations such as lubrication and cooling. It is basically claw-shaped, but with the gripping done by tightening a cable passing through each sectioned half of the claw instead of at some hinge point in the middle. Three roller bearings on each half of the claw are in contact with the part being processed. The drive for this element includes a precessional speed-reducing planetary gear train mounted in the wrist. Such drives are already operating in one of the Krasnoyarsk assembly plants and in the Istra plant (Moscow Oblast) of the "Vetroen" (Wind Energy) Scientific-Industrial Association, saving respectively 126 thousand rubles and 47 thousand rubles in annual production costs. Figures 2.

UDC 621.9.06-229

Transport Devices for Machining Prismatic Parts in Flexible Manufacturing Systems
18610186c Kiev TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 1, Jan 88 pp 18-20

[Article by Ye. S. Pukhovskiy, candidate of technical sciences, and M. A. Gonzh, engineer]

[Abstract] For automation of flexible manufacturing systems where welded steel parts up to 900x900x1200 mm^3 large and weighing up to 600 kg are machined with 2623PMF4 and SVGKI110/1 multipurpose machine tools made in the GDR, several devices have been designed to facilitate an automated storage and retrieval system (AS/RS). They include a universal palletized fixture, a transporter, a device for transporting the pallet from transporter to machine tool, a loading manipulator, and a warehouse. Mounting of the pallet on a turntable with a hydraulic cylinder is described in detail. Basic relations for on-line or postoperational inspection are established and the layout of a flexible production system with these devices is shown. Figures 3.

UDC 658.52.011.56

Hardware and Software for Automatic Control of Machine Tool in Flexible Manufacturing System
18610433a Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 4, Apr 88 pp 12-14

[Article by Ye. V. Mokhnachev, engineer, and V. Yu. Babichev, engineer]

[Abstract] An automatic control system has been developed for individual machine tools and integrated into a group control system so as to facilitate flexible manufacture of prismatic parts on the basis of the Japanese MAZ AK-H12 machining center. Its hardware consists of an Elektronika-60 control microcomputer with central processor, 16 kword of RAM, 15UZPP 8KX16-3 reprogrammable external ROM connected to the microprocessor, a switcher, switcher-drive interface, power supply, control panel, and array of transducers. The switcher, acting as a group controller, includes matching and decoupling devices as well as a sequential-data-exchange module, an input-output interface, and a synchronizer. A control module converts data coming from the switcher in a parallel code into a control voltage for the electromagnet manipulator. The power supply provides +5 V for integrated micro-circuits, plus or minus 15 V for operational amplifiers, and +24 V for transducers as well as, unstabilized, for direct-current output switches and other power circuits. The software contains algorithms for set up, programming, standalone control, and group control modes of machine tool operation, also of hardware and software diagnostic testing with the aid

of a signal simulator as well as hardware and software adjustment in the interactive mode. Figures 3; tables 1.

UDC 621.78.012.5:621.81

Integrated High-Speed Electrothermal Treatment in Automatic Facility for Broad Range of Long Cylindrical Parts

18610199 Moscow VESTNIK MASHINOSTROYENIYA in Russian No 3, Mar 88 pp 51-53

[Article by N. M. Grechko, engineer, and V. D. Zadumin, engineer]

[Abstract] An automatic induction-heating facility for high-speed electrothermal case hardening and bulk hardening of metal parts has been developed. Its productivity and product quality are better than what is now attainable, and this facility is designed specifically for processing cylindrical parts that vary widely in length. It consists essentially of three successive hardening vats which also serve as cooling vats between a loading device and an unloading device. Both loading and unloading devices are welded metal structures, while each trough-vat contains pneumatically driven horizontal and vertical carriages controlled from a central panel in the last one. The facility can process parts 300-1100 mm long and 30-150 mm in diameter, its productivity being 10-30 pcs/h. Its power requirements are 100-200 kW for heat treatment and 9 kW for the electric drives. The heating mechanism consists of three inductors and three TZ 3-800 transformers. The inductors can be shifted up to 20 mm horizontally and 120 mm vertically. They travel 1100 mm at a smoothly regulated velocity of 2-20 mm/s under load and at a fixed velocity of 60 mm/s when idling. A treated part is rotated at a speed of 80 rpm. The water pressure is at least 0.3 MPa, the rate of water consumption is 10 m^3/h, the water temperature does not exceed 30°C and 70°C at the hardening station inlet and outlet respectively. The air pressure in the mains is 0.4 MPa. The facility weighs 8840 kg and its overall dimensions are 3570x4400x12,200 mm^3. Two such units are already operating in one of the Leningrad Tube Treatment plants. Rolled tube stock of 40Cr steel for semiaxles of the "Kirovets" tractor is induction hardened here at a temperature of 400°C, after preliminary machining and heat treatment. The surface hardness of 590 mm long segments 140-150 mm in diameter is increased from initial Bhn 207-302 to Bhn 229-269 or HRC 45-50 after the third stage. Figures 2; tables 1.

UDC 621.974.813:658.011.56

Automated Production Unit for Cold Radial Reduction of Tubes

18610121 Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 8, Aug 88 pp 27-29

[Article by B. F. Surinov, L. A. Butenko, L. A. Yefimova, Sh. R. Vartanyan, G. V. Kuznetsov and V. M. Kudrik]

[Abstract] An automated production unit AKP 1938 has been built jointly by the Experimental Scientific Research Institute of Forging and Pressing Machinery and the Rostov Scientific Research Institute of Machine Manufacturing Technology for cold radial reduction of cylinder sleeves to nominal size within tolerances. The unit consists of a 6.3 MN press with a hydraulic-crank pressure booster and a rack. The plunger makes at least 400 double strokes per minute, the working length of a stroke being 2.5 mm. A tube blank is fed up to 5 mm by push and up to 10 mm by pull, at a rate of up to 3 m/min during the working part of a stroke and up to 30 m/min during the idle part. It is rotated at speeds of up to 30 rpm, with smooth regulation. The feed mechanism can take up an axial force of 150 kN maximum. The press is designed for blanks with 40-150 mm outside diameter, up to 6 mm long and weighing up to 250 kg, for up to 10 mm long sleeves. The main drive has a 75 kW motor. Experimental and pilot production runs accdording to standard specifications have yielded excellent results: blanks with outside and inside diameters within tolerances but wall thickness variation and wall curvature beyond tolerances can be reduced to sleeves completely within tolerances including those on surface roughness and with the depth of surface defects decreased by more than 50 pct. The unit should save 0.5 million rubles in production cost and 200 tons of metal annually. Figures 2.

UDC 621.961.02

Advanced Technology for Production of Shearing Dies

18610187a Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 3, Mar 88 pp 11-14

[Article by V. V. Kulikov, A. G. Bobrov and I. Ye. Rudnev]

[Abstract] A new computer-aided technology of producing dies and punches for intricate stampings with cutouts by the electric discharge process has been developed and introduced at the Volga Automobile Manufacturing Plant which ensures high productivity and stability of the stamping tools as well as high precision (plus or minus 0.05mm) and fine surface (Ra=0.63μm) of stampings. In the new method, plates of copper or another high-conductivity material are stacked together and are then machined with three tool electrodes of a wire-type NC-controlled electric discharge machine tool. The first one lays out the die holes as well as the plunger and ejector profiles, whereupon the second electrode does the finishing electric discharge machining. The third electrode then burns out the hole for the punch. Computer-aided design and fabrication of die and punch take into account the material and the dimensions of stampings to be produced with necessary allowances and tolerances. This technology requires 35 fewer man-hours per set than the conventional one, eliminates bench work, produces equipment with 1.5 times longer life, and provides for full interchangeability of parts. The applicability of

blanking and piercing is discussed as it relates to sturdiness of the die, part geometry, and the metal sheet material properties. Figures 7; tables 1; references 1: Russian.

UDC 621.98:658.512.001.56

Preparation of Control Programs for Group Production of Parts From Sheet Stock in Coordinated Turret Lathe Machining Center
18610187b Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 3, Mar 88 pp 16-17

[Article by B. F. Flaksman, V. T. Linovetskiy and Ye. I. Ostroverkhova]

[Abstract] Computer software and hardware have been developed for preparing numeric program control of group production of parts from sheet stock in a coordinate turret lathe machining center at the end of a flexible automatic forging and pressing line, blanks having been cut from the sheet with shears. The program preparation consists of five steps: 1. describing the blueprint and filing the description in the library, 2. supplementing the description with tool numbers and other identification, 3. checking the filed description for errors, 4. generating the control program, 5. entering the coded description after debugging in the central databank. The hardware for program preparation on an SM-4 minicomputer with given parts description library and tools list consists of a switcher, a translator, a postprocessor, a servicing module, and a video terminal. Subsequent generation of control programs for a turret module controlled by an Elektronika-60 microcomputer requires also a file of strip cutting charts and a temporary-code file. Figures 2; references 4: all Russian.

UDC 620.175.22(088.8)

Effect of Elastic Aftereffect on Contact Stiffness of Metal-Cutting Machine Tools in Automatic Manufacturing Lines With Rotary Drives
18610408c Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 3, Mar 88 (manuscript received 5 Feb 87) pp 126-130

[Article by G. S. Ivasyshin, candidate of technical sciences, docent]

[Abstract] The elastic aftereffect associated with stiffness hysteresis in loading-unloading cycles, understood in physical terms of dislocations and resulting linear imperfections of the crystal lattice caused either by cold creep or by thermally-activated motion, is first described on the basis of Mott and Konyakhin theories for analytical calculation of the contact strains in surface protrusions of ideally regular geometrical shapes. The theoretical relations and experimental data are then applied to metal-cutting machine tools such as punches with two types of rotary drives common in automatic manufacturing lines; cams and free-run rollers. Evaluation and analysis of the data reveal that the contact stiffness depends largely not only on the elastic aftereffect but also on the initial displacement. Contact stiffness as well as wear resistance and fretting resistance in such mechanisms can, according to friction test data on several steels, be improved by optimizing the selection of materials. Figures 1; references 9: Russian.

UDC 681.3

Hardware for Development of Artificial Brain (Tensor Method)

18610045 Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian No 7, Jul 88 (manuscript received 3 Nov 87) pp 3-5

[Article by A. Ye. Armenskiy and N. G. Miloslavskaya, Moscow Institute of Engineering Physics]

[Abstract] A geometrical translator which utilizes available tensor database management and a categorial translator are considered for execution of algorithms on a computer, inasmuch as any algorithm executable on a computer can be formulated as a set of tensor equations with a control matrix consisting of predicates, zeros, and ones. A geometrical translator operating with TOPAZ input language transforms, by dual transition, a programmed algorithm into systems of algebraic equations of various orders. Variables, except substitution variables, as well as constants are treated as constant coefficients in some other algebraic equations. The translator determines one set or several sets of algebraic equations whose solution is the given algorithm. This is demonstrated on solution of a quadratic equation using the PASCAL program, the translator finding the two equations for the sum and the product of its roots, and on representation of a function in the form of two systems of recurrence equations. A categorial translator operating in PL/1 language verifies the correctness of that transformation, with mandatory two data items as commentary on the dimensionality of physical quantities inserted in the form of the Bartini-Kuznetsov $L^{r}T^{s}$-table (L- space dimension, T- time dimension). References 4: Russian.

UDC 628.517.2

Suppression of Exhaust and Intake Noise in Reciprocating Compressors

18610402 Moscow KHIMICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 88 pp 45-47

[Article by A. M. Korobochko]

[Abstract] Reactive mufflers, combinations of chambers with connecting tubes without a special sound absorbing device, are considered for noise suppression in reciprocating compressors in preference to active mufflers on account of simpler construction and lower cost. On the basis of a performance analysis, assuming a known noise spectrum and taking into account not only exhaust noise but also intake noise with attendant aerodynamic losses, the mathematical model of a chain fraction is selected as suitable for solving the problem with so many interdependent parameters. The computer programs developed at the Leningrad Institute of Construction Engineering include also one for design optimization, namely minimization of a target function which in this case is the aerodynamic insertion loss with the muffler in the intake channel. The problem reduces to minimizing the cross-sections of the muffler chambers to sizes necessary and sufficient for noise suppression. Such a muffler has been designed for the VP20/8 compressor with an inlet air velocity of 10 m/s. The muffler consists of three chambers tuned to 125 Hz, 250 Hz, 500 Hz respectively. The compressor noise under laboratory conditions simulating operation in the Leningrad "Positron" station was reduced with it by up to 20 dB. Figures 2; tables 2; references 4: Russian.

UDC 691.327.666.973.2:539.4

Possibility of Lowering Cement Content in Cellular Concrete

18610019 Moscow BETON I ZHELEZOBETON in Russian No 7, Jul 88 pp 7-9

[Article by A. P. Merkin, doctor of technical sciences, professor, Moscow Institute of Construction Engineering, G. O. Meynert, engineer, and N. P. Sazhnev, candidate of technical sciences, Scientific Research and Construction Planning Institute of Silicate Concrete, A. V. Dombrovskiy, candidate of technical sciences, ESSR State Committee for Construction, and V. P. Varlamov, candidate of technical sciences, All-Union Scientific Research Institute of Building Materials and Structural Parts]

[Abstract] The possibility of lowering the cement content in cellular concrete and still maintaining the structural characteristics on a par with those of the best concretes made in foreign countries has been demonstrated as a result of research by Soviet institutions in an energy and raw materials conservation program. Experimental data and theoretical analysis indicate that not a higher cement content but a lower water content will ensure adequate quality of concrete. The gist therefore is to optimize the structure of the material so as to minimize the amount of sealed-in water, which can be achieved by technological means such as dynamic mechanical action and chemical additives. The impact technology developed at the Scientific Research and Construction Planning Institute of Silicate Concrete yields mixes with the water-to-solids ratio as low as 0.4-0.3, the strength of the concrete meanwhile depending largely on the quality of the Ca-hydrosilicate binder. The binder would be most efficient when formed in the absence of cement altogether, but cement is required not only for acceleration and stabilization of this concrete forming process, especially when low-grade lime is used, but also for ensuring adequate frost resistance and particularly under conditions of repetitive freezing-thawing cycles. The frost resistance of cellular concrete has been found to increase as the water-to-cement ratio is decreased so here again the cement content can be decreased if the water content is decreased even more. For cellular concrete of 600 kg/m^3 density the cement content should be within 60-80

kg/m^3, for cellular concrete of 500 kg/m^3 density it should not exceed 70 kg/m^3. Tables 3; references 7: 5 Russian, 2 Western (both in Russian translation).

UDC 622.24.051.71

Diamond Rock-Crushing Tool Developed at Central Scientific Research Institute of Geological Exploration

18610099 Moscow RAZVEDKA I OKHRANA NEDR in Russian No 9, Sep 88 pp 29-34

[Article by Yu. Ye. Budyukov, L. L. Volkov, I. A. Baskilovich and M. Ye. Grenader, Department of Experimental Research, Central Scientific Research Institute of Geological Exploration]

[Abstract] Following preparatory basic theoretical and experimental studies toward development of a special diamond rock-crushing tool for use with coring single-ejector and double-ejector coring cartridges, on the basis of pressure distribution analysis and measurement, such a tool has been technologically designed with diamond bits used for coreless drilling. Research and development of drilling equipment, progressing over the 1966-85 period along with intensification of drilling activity during this period, have yielded diamond drill bits for rocks of every drillability class ranging from highly comminuted class XII rocks for which single-ejector cartridges are preferable to more shaky nonuniform-hardness class VI rocks for which double-ejector cartridges are preferable. Most energy efficient are diamond crown bits plainly stepped or stepped with serrations. These bits, their design tailored for specific drilling volumes and average drilling speeds, are used throughout the USSR where geological exploration continues. Figures 2; tables 2.

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